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An important test of 18-in. nickel-steel Harveyized armor plate took place at Indian Head on March 11. The plate was made by the Carnegie Co., and was a sample of 300 tons to be used as side-armor on the battle-ship "Oregon." The plate weighed 38 tons, and was subjected to the fire of a 12-in. gun at 200 ft. range. The plate measured 17 × 7½ ft., was 18 ins. thick in the thickest part, and at a point 3 ft. from the base it was beveled down to 8 ins. to meet the protective deck. The first projectile fired was of the Carpenter type, and a powder charge of 295 lbs. was used. This shell struck the thickest part of the plate, penetrated 4 ins. and left the point of the projectile welded in the plate; the remainder of the shell flew into fragments. No radical crack followed. In the second shot from the same gun, the powder charge was increased to 395 lbs., giving an initial velocity of 1,956 ft. per second. This shell struck 2 ft. to the right of the first shot, entered 7 ins., and the shell was again broken, leaving the point imbedded. A long vertical crack was made extending from the top to the bottom of the plate; but it was so narrow that it was difficult to determine how deep it extended, and there were no longitudinal cracks. The test was deemed thoroughly satisfactory, and the armor it represents will be accepted. At the same time a 9-in. cast steel chromium-hardened plate was submitted for test by the Midvale Co. This plate is cheaper to manufacture than forged plate, and 2 ins. of the face only was hardened by chromium; the remaining 7 ins. being plain steel without nickel alloy. A shot from a 6-in. rifle, with an initial velocity of 2,156 ft. per second, penetrated only 3 ins., but caused a break clean through the plate. As the officers present expected a clear penetration, with a shattered plate, the result was deemed fairly good.

The 40-ton travelling jib crane for the Mare Island navy yard has been tested and found satisfactory. The crane is carried on 20 double flanged wheels, running on a track of 20 ft. gage, laid with 100-lb. rails, along two sides and the back of the dock, the curves being 66 ft. radius. The total height to top of boom is 54 ft., and the total width is 24 ft. The crane weighs 200 tons, and has a counterbalance of 120 tons. It can be revolved in two minutes, and hoists 40-ton loads at 7 ft. per minute, and 15-ton loads at 15 ft. per minute. It was built by the American Hoist & Derrick Co., of St. Paul, Minn.

Combination open and closed electric cars are being introduced by the Milwaukee Street Ry. Co., of Milwaukee, Wis. They are 40 ft. long, one-half being closed and the other open, the latter having transverse seats, and each part seats 18 passengers. The cars are carried on two four-wheel trucks, and are lighted by 15 electric lights.

The speed of a large number of the electric cars in Brooklyn, N. Y., is being measured by special inspectors. On one day 13 cars were reported as making from 12 to 20 miles per hour, and on the next day 20 out of 24 cars timed exceeded the limit of ten miles per hour. A large number of cars have been timed, two men riding on each car and noting the time of starting and stopping, the distances being afterwards measured. Speeds of 12 to 20 miles an hour were common, the maximum being nearly 30 miles. The records show that the cars run at 16 to 20 miles per hour past the public schools.

The Sioux City (Ia.) elevated railway, 1½ miles long, with 3½ miles of surface road, running into the suburbs, was sold, with all equipment, on Feb. 23 to Mr. D. M. Robbins, of St. Paul, Minn., for $50,000. This elevated road consisted of a double-tracked steel structure, and was built, to be operated by steam, in 1890-91, at a cost, without equipment, of $200,000. It was afterward remodeled for operation by electricity. The road has been in a receiver's hands for three years, and was sold at Sheriff's sale to pay liens amounting to $28,000, the receiver's expenses and cost of changing motive power, taxes, etc., amounting to $30,000. Mr. C. F. Loweth, M. Am. Soc. C. E., of St. Paul, Minn., was chief engineer when the road was built.

Private observation electric cars have been built by the Laclede Car Co., of St. Louis, Mo., for the Philadelphia Traction Co. and the New Jersey Consolidated Traction Co. Each is a four-wheel car, elaborately decorated and finished, the body forming a saloon, fitted with upholstered chairs, lockers for refreshments, etc. The platforms are of exceptional length, 5 ft. 6 ins. long, enclosed by ornamental railings, and having seats against the ends of the body. The cars are 16 ft. long over the body, 28 ft. 9 ins. long over all, 7 ft. 6 ins. wide over the body, 6 ft. 6 ins. wide over the sills and 11 ft. 7½ ins. high from rail to top of trolley board on the roof.

The most serious railway accident of the week was a collision caused by a misplaced switch on the Southern Ry., near Scotland, Ga., March 8. The switch is said to have been opened by train wreckers, and the Florida vestibuled express was turned onto a side-track, where it collided with a number of freight cars. The train consisted of three Pullman cars, two day cars and a mail and express car, all of which were derailed, some of the cars being overturned. Two of the passengers were killed and about eight injured.

The rear driving axle of a Boston & Maine R. R. locomotive hauling a passenger train into the Boston union station on March 6 broke near one of the wheel seats while the engine was crossing the Charles River drawbridge. One of the driving wheels fell into the water, and the side rods were bent out of shape, but the engine was stopped before it had run many feet.

The falsework of the Neosho River bridge on a coal branch of the Missouri, Kansas & Texas Ry., near Parsons, Kan., collapsed Feb. 28, throwing three men into the river.

A locomotive boiler explosion occurred March 9 on the Pennsylvania R. R. The engine was hauling a westbound express train, and was running at high speed near Cove, Pa., 11 miles from Harrisburg, when the accident occurred. The engine was thrown into the air, and the mail and baggage cars were derailed. The fireman was killed, and the engineman seriously injured.——A similar accident occurred March 2 on the Georgia Central R. R. The engine was hauling a freight train near Weems, Ala., when the boiler exploded, killing the engineman and fireman, while several cars were derailed by the shock.

An improperly covered blast in an excavation at 103d St. and West End Ave., New York, on March 8, threw rocks in all directions, doing serious damage to a number of neighboring buildings.

An explosion of natural gas occurred at Anderson, Ind., March 5, almost completely wrecking an entire business block, and involving a loss of $400,000, while streets were torn up by the explosion and much damage caused by the flying debris.

The deepwater terminal property at Halifax, N. S., was practically destroyed by fire Feb. 27, the loss in property and freight amounting to about $1,000,000. The fire was started by the heater on a freight car, and soon extended to the wharves, freight sheds, bonded stores, coal yard and several ships.

A large stern-wheel passenger steamer on the Ohio River was wrecked March 8 at Cincinnati, O., by striking sideways against one of the channel piers of the Chesapeake & Ohio Ry. bridge. The steamer was the "Longfellow," of the Cincinnati, Memphis & New Orleans Packet Line, and was starting on a regular trip to New Orleans, but in approaching the bridge was caught by the current and dashed against the pier, on the Kentucky side of the river, the force of the current breaking the boat in two. Fortunately the company's harbor boat was close at hand, trying to assist the vessel in the dangerous passage, and most of the 40 passengers were rescued by this steamer, but two passengers and three of the crew were lost.

The inquiry as to the cause of the collapse of the four flat-houses on Orchard St., New York, noted last week, has resulted in a verdict by the coroner's jury to the effect that the accident was due to faulty design, careless supervision of the plans, criminally bad construction and criminally negligent inspection. The opinion was given that the Building Department and its system of examining plans and inspecting buildings need a thorough reorganization.

The North Sea Canal will be officially opened to traffic, by Emperor William, on June 20 next. This canal connects Kiel, on the Baltic Sea, with Brunsbuttel, on the River Elbe, below Hamburg, crossing the Prussian province of Holstein. Work was commenced on June 3, 1887. Its length is 53½ miles; average depth, 29½ ft.; bottom width, 72 ft., and width at water surface, 213 ft. The speed allowed in passing will be 5.3 miles per hour, and the toll will be 18 cts. per net register ton, loading capacity. It is expected that about 18,000 ships, representing 7,500,000 tons, will use the canal annually, and thus avoid the passage from the North Sea to the Baltic by way of the Skager Rack and Cattegat. Ships bound to Bremen will save 322 miles, and those to Hamburg 424 miles, while German warships can now pass to the North Sea without going through foreign waters. The estimated cost of $37,440,000 was not exceeded. Full details of this canal were given in Engineering News of Aug. 1, 1891, and March 26, 1892.

The report of the U. S. Commissioner of Patents for the year ending Dec. 31, 1894, says that out of 38,344 applications for patents, 20,803 were granted, and 12,920 patents expired. In proportion to population, Connecticut obtained more patents than any other State, 1 to every 993 inhabitants; Massachusetts came next, with 1 to every 1,335, and the District of Columbia had 1 to every 1,379 inhabitants. The total expenditures of the office for the year were $1,100,047.12, and the receipts exceeded expenditures by $87,392.46. Th total balance in the U. S. Treasury to the credit of the U. S. Patent Office is $4,369,135.91.

The income account of railways in the United States for the year ending June 30, 1894, is separately published by the Interstate Commerce Commission. Its chief points are given in the Eight Annual Report, reviewed in our issue of Dec. 13, 1894; but among the newer information is a statement of defaulting railway corporations. On June 30, 1894, 156 railways were in the hands of receivers, 106 of which failed in the fiscal year 1893-94. These lines aggregate 38,870 miles in length, and represent a total capitalization of $2,500,000,000, about one-fourth of the total railway capitalization of the country. In this list 28 important companies represent about 80% of the total mileage and 79% of the total capital involved. The commission goes on to say that investigation shows that these 156 lines were burdened with indebtedness difficult to carry in prosperous times, and out of the total only 28 lines had paid any dividends to stockholders in the last 14 years.

A cable tramway, located 30 ft. above the crest of Niagara Falls, is projected by the Aerial Tramway Co., now asking a charter from the New York legislature. The company proposes to erect towers and landing stages on each side of the river, and to stretch a double set of cables across the river, over the Horseshoe fall. From these cables a passenger car would be suspended by trolleys, and would be run back and forth by electricity. The cables would each have a safety factor of ten, and the car could be stopped anywhere on the line. Mr. George W. Pound, of Lockport, N. Y., is one of the directors of the company.

The East River bridge, to connect Broadway, Brooklyn, with Grand St., New York, may be built by the city of Brooklyn, the Mayor of that city having directed the preparation of a bill for this purpose, and it is understood that the bridge company, which has been hindered by financial difficulties, will make no opposition.

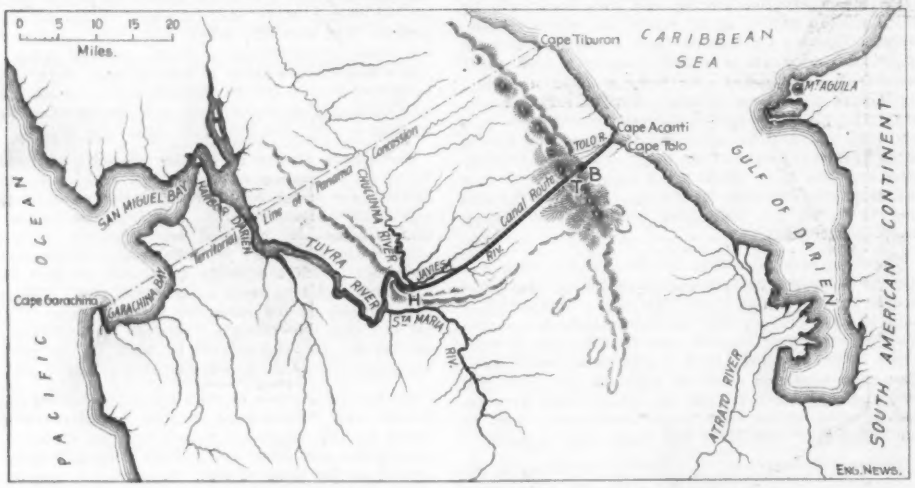
Work on the erection of the large highway bridge over the Mississippi River at Red Wing, Minn., is progressing rapidly. The piers are all in, and the main span, 420 ft. long, and the Red Wing approach, are nearly completed, and the falsework, 68 ft. high, which was erected on the ice, has been removed. All material, about 550 tons, is on the ground, and Mr. C. F. Loweth, M. Am. Soc. C. E., of St. Paul, chief engineer, states that the work will be completed about April 15. Mr. H. L. Hammond is superintendent of erection for the Toledo Bridge Co., the contractors, with Mr. W. E. Schroeder as assistant. Mr. L. P. Wuiff, City Engineer, is in charge of the city's interests.

A NEW DARIEN SHIP-CANAL ROUTE.

For some time past items have been going the rounds of the daily press, stating that Mr. Gustavus A. Karwiese had discovered a very short and comparatively cheap route for a ship canal to connect the waters of the Atlantic and Pacific oceans. We are now enabled to present this project to our readers, through the courtesy of Mr. Frederick M. Kelley, who has for the last 30 years been prominently identified with Isthmaic ship-canal enterprise.

Mr. Karwiese, in letters now before us, claims that he has been investigating ship-canal routes in Central and South America for the last 28 years, and has personally made eight instrumental surveys of the route he here presents; though he says that more elaborate and costly investigation would have to be made before exact estimates of cost could be furnished.

Unfortunately for our purpose, the only data available for a description are the accompanying sketch map and the statements and estimates of Mr. Karwiese himself, confessedly founded upon somewhat uncertain data and information. This material is, therefore, given merely for what it is worth, as an addition to American interoceanic canal literature.



A PROPOSED ROUTE FOR A DARIEN SHIP CANAL.

As shown on the accompanying map, his canal route lies through the state of Colombia, between the Gulf of Darien, on the Atlantic side, and the Bay of San Miguel, on the Pacific side. The greater part of the route lies to the south and outside of the territory included in the Panama Canal concessions made by the state of Colombia. Mr. Karweise says that, commencing on the Pacific side, there is about 11 miles of free navigation up the Bay of San Miguel and the Tuyra River, and he proposes to dredge out and rectify the remaining part of this river up to the point H, on the map, where he locates his first tidal lock, about 60 miles from the Pacific along the present crooked course of the river and bay. He claims that there is 38 ft. of water for about 11 miles of this line and that over the remainder dredging is easy.

He commences what he calls his canal proper at the point H and follows the Javiesa River and valley until the main ridge of the Cordilleras is reached at T, where he proposes a tunnel 11,880 ft. long, through the mountain. His canal terminates between Capes Acanti and Tolo, on the Gulf of Darien, in a naturally protected harbor. The length of this section he fixes at 28⅝ miles; that is, from the lock at point H to the Darien entrance lock at B. And from the Pacific Ocean to the Gulf the distance would be about 93½ miles, on the line described.

The summit of the Cordilleras at the point tunnelled is 1,180 ft. above sea level; and, as he proposes a tunnel 88 ft. wide and 112 ft. high, this would leave nearly 1,000 ft. of solid rock over the crown of the tunnel. For the 28⅝ miles of canal excavation he proposes a width of 88 ft. and a depth of 28 ft. 8 ins. He estimates that this would allow two ordinary ships to pass each other; but for the river course on the west he plans a width sufficient for the passage of four ships abreast; but does not give exact dimensions.

He says that the approaches to the tunnel will be in rock, and the cutting will average 188 ft. deep for about 1,800 ft. on each side. His total estimate of cost for the canal is $48,000,000. In this he estimates $11,000,000 for the tunnel, though he says Chicago contractors figure it at $8,000,000. It should be said that at the eastern end the River Tolo lies on the line of the canal, and this he proposes to dredge out for 2½ miles, to the point A. From the mouth of the Tolo River to the point B, where he proposes an entrance lock, is 5 miles.

THE DESIGN OF LOCOMOTIVES FOR FAST PASSENGER SERVICE.

By Hugh Sharp.

As yet no distinctive type of locomotive has been evolved which can be accepted as indisputably superior to any other for fast express service. The Baldwin "Columbia," for instance, and the New York Central "999," both doing the same class of work, have little in common but the size of their driving wheels. An examination of European practice shows no more distinct tendency toward the general adoption of a single type. European locomotive designers still retain their predilection for inside connections, notwithstanding that almost everywhere else inside cylinders have been tried and abandoned. In the same way locomotives with a single pair of drivers are still peculiar to Great Britain, notwithstanding the fact of their success there. The bulk of the fastest and heaviest passenger service on the Midland, Great Northern, and Great Western railways is successfully performed by single-driver locomotives.

On the continent of Europe the compound system is making headway, nearly every practicable arrangement being represented. In Great Britain, however, the system, after an extended trial, has been practically abandoned, except on the London & Northwestern. It is, perhaps, premature to offer any decided opinion as to the future of compounding in this country; but there appears to be a growing feeling that for fast passenger service, it presents no advantages over single expansion.

In this country many details of construction have been decided purely by local conditions and requirements, and therefore require no comment; but our standard practice regarding framing and attachment of the cylinders to the boiler by means of half-saddles cast solid with the cylinders, finding no counterpart outside America, is worth remarking. Considered as a disposition of a given amount of metal to secure a girder of maximum strength, the time-honored bar frame is obviously inferior to the slab; and where head-end collisions need not be allowed for, and where solidity of track calls for no excess of elasticity over and above that provided by springs and a flexible wheel-base, its retention is of doubtful utility. In some recent tenders the slab form has been utilized, and this may be the thin end of the wedge which will eventually dislodge the bar frame from favor. The casting of half-saddles and cylinders together is objectionable on account of the excessive weight imposed on the truck axles—an objection which is intensified in the case of modern high engines, where boilers of large diameters are necessarily carried above the driving wheels.

Although there is no immediate prospect of a universal set of types, it is certain that during the last few years European and American practice have been largely acting and reacting on each other, and that important modifications have been produced. In this country there is, at last, an unmistakable disposition to use large drivers where high speed is sought, and avoid excessively high piston speeds. The general opening out of exhaust tips, with a consequent reduction of back-pressure, is also characteristic of recent practice, and in both instances is following a lead set by Europe for many years. On our side, we may fairly claim to have originated a locomotive having high driving wheels, the shortest possible rigid wheel-base, and a boiler of 5 ft. or more in diameter carried above the driving wheels—in short, to have proved that a high center of gravity is perfectly compatible with safety at the highest speeds. In boiler pressures we have been in the van for years, and the phenomenal speeds recorded in recent years would not have been possible had we confined ourselves to 160 lbs. to the square inch, a pressure which, with rare exceptions, is not exceeded in Europe. Modern American practice favors the conjunction of great heating surface with comparatively moderate cylinder capacity. Engines with 72-in. to 82-in. driving wheels and 19×24-in. cylinders will very generally have 1,600 sq. ft. of heating surface, or more; abroad, it is common to find 18 × 26-in. cylinders and 1,200 sq. ft. of heating surface. Climate is doubtless partly responsible for the great boiler capacity usually provided here; but mainly, I think, the necessity for making connections over very long distances (a necessity which is not felt to anything like the same extent in Europe) has rendered it imperative to have an engine with a large reserve of boiler power to draw upon, capable of steaming freely under the most unfavorable conditions of weather, and of making up time where schedules exceed 40 miles an hour. Travellers in Europe notice that lost time is very seldom made up, and that bad weather and late trains accompany one another with a certainty which would not be tolerated on this side of the Atlantic. Until recent years the extended smokebox was seen only in America, but it is now occasionally found in continental Europe. In Great Britain it has not met with favor in its extreme development, but its influence may be traced in the more liberal proportions which designers in that country now generally assign to their boxes. The wagon top still remains distinctively American, and its use permits the throttle being situated immediately over the crown-sheet, where the steam is hottest. Many years ago this was the usual position of the throttle in Europe, but the intake is now usually from the center of the barrel, or even further forward. The change of position was adopted to avoid the effects of priming caused by the violent ebullition over the crown-sheet, where there was insufficient steam-room to permit the entrained water freeing itself from the steam before the latter reached the intake. That the amount of valve travel, port area and proportion, lap and lead calculated to give the best results should still be in doubt can only be accounted for by the apparently contradictory results obtained in actual practice. The particulars of four representative locomotives contained in the annexed table go to prove that English practice favors relatively small port area, short valve travel, and considerable lead; the heating surface and dimensions of cylinders are also quoted to bear out the statements made above.

Builders.	Total heat. sur., sq. ft.	Cylin. dimen., ins.	Port dimen., ins.	Lap. ins.	Lead in full gear. ins.	Valve max. trav. ins.
Man., Sheff. & Lin.Ry.(Eng.)	1,278	18×26	1⅝×16	1	9-64	4 5-64
C. R. R. of N. J.	1,708	20×24	1½×20	1	1-16	6½
N.-East. (Eng.)	1,341	19×26	2 ×14	1¼	⅛	4¾
N. Y. Central & Hudson Riv.	1,930.37	19×24	1¼×18	1	1-16	5½

AUXILIARY SUPPLY OF THE WATER-WORKS OF ADDISON, N. Y.

By H. F. Labelle, Constructing Engineer.

The water-works of Addison, N. Y., are supplied by gravity from an impounding reservoir on the east side of the town. This reservoir is formed by a handsome masonry dam, which impounds about 1,000,000 gallons of water. It is supplied from springs located within a half mile above the dam. The works were built in 1889 by the Addison Water Co.

Occasionally, when the summer is very dry, these springs fail to give the necessary quantity of water required for consumption. To supply this deficiency, an auxiliary well and pumping plant was designed and established in the summer of 1892.

The plant was located on the west bank of the Canisteo River, which flows through the town. This part of Western New York lies on the southern boundary of the glacial drift and water-bearing gravel is found in abundance in the valleys of the rivers.

As the auxiliary plant was to be intermittent in operation, it was deemed economical and convenient to establish the pumping station and the well near a sawmill, from which the necessary motive power would be supplied.

The supply well is 12½ ft. in diameter and 23 ft. deep from the surface of the ground. The excavation of the well was carried out in the following manner, as may be better understood by referring to the accompanying plans and sections. A 50-HP. engine was put in position near the excavation. Two pulleys were used on its driving-shaft, the first belted to a 6-in. centrifugal pump, placed in the excavation about 8 ft. below the surface and just above water level; the second was used in connection with a bull-wheel as a friction wheel. On the drum of this bull-wheel was coiled a ⅞-in. manilla rope, which went up to a grooved pulley placed at the top of a small four-legged derrick and then dropped to the bottom of the well to operate the buckets. The derrick rested on two 12×12-in. timbers, 20 ft. long, spanning the excavation.

A system of levers operated from the platform under the derrick worked the bull-wheel forward towards the friction wheel, or backward towards a 6×6-in. horizontal frame, the sides of which supported the bull-wheel pillow-blocks, and the back end was used as a brake for the bull-wheel.

This arrangement permitted us to run the centrifugal pump independently of the hoisting of the buckets. Besides, the hoisting apparatus was completely under control of the man placed on the platform under the derrick. A 3-ft. tramway was established on the river bank, with one end running under the derrick. A small four-wheel flat car was run under the loaded bucket as it came out of the hold, and was taken away to be dumped whilst the next bucket was being lowered and filled. The excavation had to be strongly timbered and tightly sheeted, as the ground was very soft. The excavation was stopped at 24 ft., as 8×6-in. timbers were beginning to crush. The bottom was then floored with two thicknesses of 2×6-in. hemlock laid on 4×6-in. mud sills, and a sump left for the pump suction.

At this stage of the work the amount of water coming into the well was small and flowing mostly from a 3-ft. vein of gravel, 4 ft. above the bottom, and from which the neighboring wells were taking their supply. As this vein was exposed to contamination, it was discarded, and water obtained from three seams located, respectively, 7, 14, and 20 ft. below the bottom of the well, and separated from one another by beds of clay. The size of driven pipe which gave the best results was 1½-in. In the lower 3 ft. of these pipes were drilled 150 3-16-in. holes, and the end was forged to a point. To test the yield of each vein, the water was pumped out of the well, and the flow in the same during five minutes measured; when the last two pipes driven did not give any increase in flow, from the previous gaging, no more pipes were driven in that seam, and the next seam was tapped. Twenty-three pipes were driven altogether in the three veins, giving a supply of 165,000 gallons per day.

A 20-in. wall in cement was built from the bottom to 9 ft. below the surface. At that level the well was covered with large flagstones supported on 70-lb. rails, and in the center was placed the shell of an old 4×10-ft. boiler, to form a manhole.

This manhole projects 18 ins. above the surface of the ground, and is capped with a cast iron cover having a 24-in. opening, also supplied with cover; the excavation around the manhole is filled to the surface.

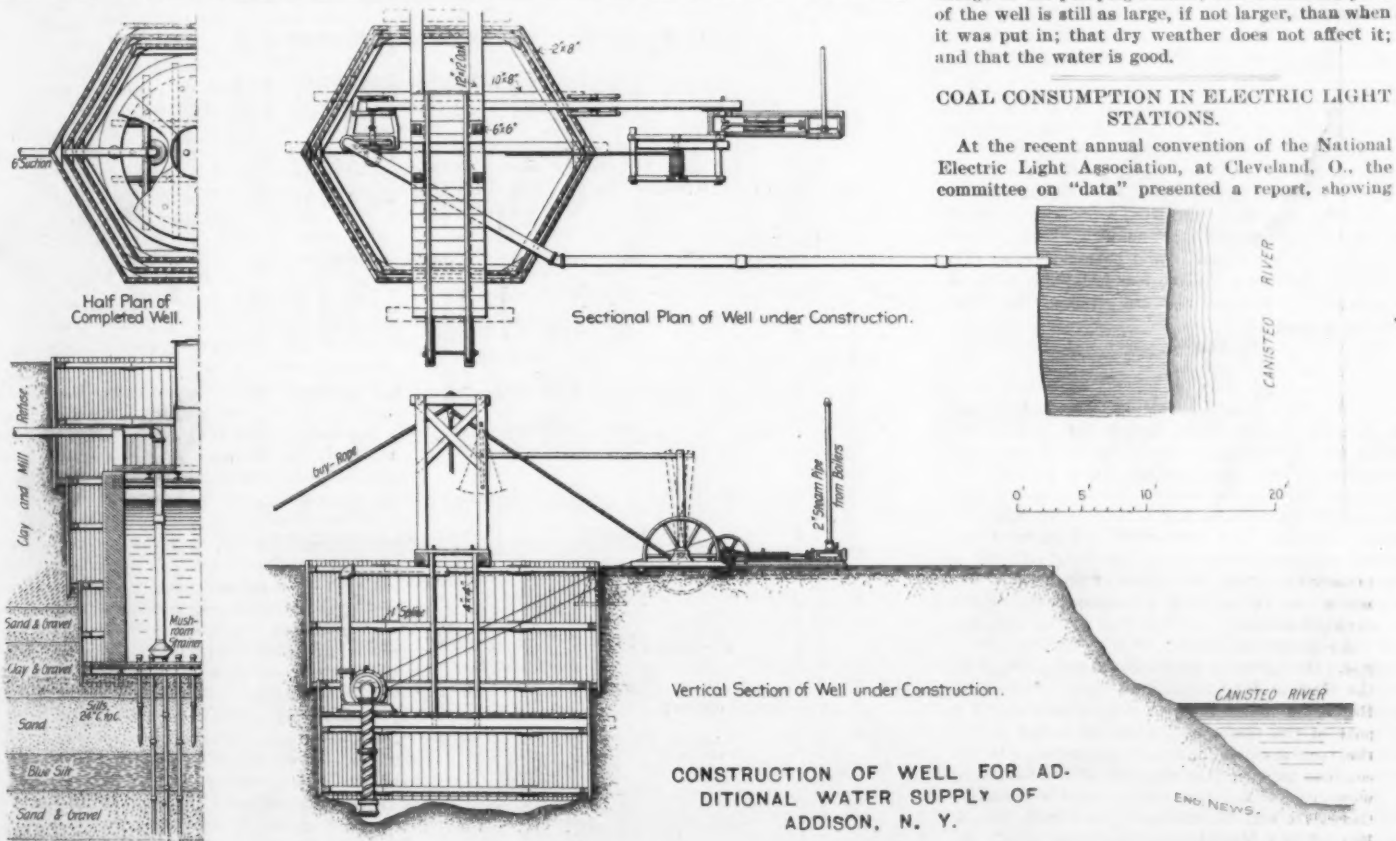
The pumping station is a substantial stone building built close to the well, and containing a 500,000-gallon Worthington duplex compound condensing pumping engine, operated by steam supplied from the saw-mill boilers. Provision has been made in the suction main for extensions to another supply well, or to a system of driven wells.

The cost of the plant was as follows:

156 cu. yds. excavation (including 2-in. hemlock sheeting) @ $2.18	$340
34.4 cu. yds. stonework in Rosendale cement, @ $5.82	200
90 lin. ft. rails (70-lb.)	26
Flagging	9
Manhole	52
Backfilling	10
Piping	104
Sundries	10
Superintendence	100
Total cost of well	$851
Pumping station, setting of machinery and superintendence	723
	$1,574

The Stanwix Engineering Co., Rome, N. Y., were the designing engineers, and the writer was the constructing engineer.

In a recent letter Mr. F. H. Wheaton, who is in charge of the pumping station, states that the yield of the well is still as large, if not larger, than when it was put in; that dry weather does not affect it; and that the water is good.



CONSTRUCTION OF WELL FOR ADDITIONAL WATER SUPPLY OF ADDISON, N. Y.

COAL CONSUMPTION IN ELECTRIC LIGHT STATIONS.

At the recent annual convention of the National Electric Light Association, at Cleveland, O., the committee on "data" presented a report, showing the records of fuel economy attained by 24 different electric lighting stations. In our issue of March 15, 1894, we published the report of the committee made at the convention in 1894, which showed an average current output of only 91.7 watts per lb. of coal. The present table is claimed by the committee to be more correctly and carefully compiled than any presented at any previous convention, and shows a more creditable record for fuel economy, on the whole, than that presented last year. The stations reported in the table include various styles of equipment. Thus any central station manager, in comparing his records with those given in the table, can select those of stations with equipment similar to his own.

The highest economy in the table is shown by a station which develops 262 watts per lb. of coal burned, the total output during 24 hours being nearly 23,000,000 watts. This station has triple-expansion engines with the dynamo on the engine shaft, and horizontal hand-fired water tube boilers, with heaters, but without economizers. The fuel used is half soft coal and half anthracite screenings.

Averaging the ten reports in the table from stations with an output above 5,000,000 watts per 24 hours, we find their average record to be 147.5 watts per lb. of coal, equivalent to a coal consumption of about 4 lbs. of coal per I. HP.

In discussing this report, Mr. W. R. Gardner, of the Pittsfield, Mass., Electric Co., read a report of a test which he had carried out to find the percentage of operating expenses in an electric station assignable to different heads. The test was for 24 hours, during which the total output was 4,313,846 watt-hours. The results of the test are summarized as follows:

Item.	Percent. of total cost.
1. Cost of steam (coal and water only)....	33.8
2. Cost at throttle of engine (= Item 1 plus wages of firemen, repairs of boilers, interest on boiler room investment, fire and boiler insurance on same, depreciation on boilers at 5%)	40.0
3. Cost at switchboard (= Item 2 plus wages of engineers, dynamo tenders, mechanic and wiper, repairs electric and steam plants, oil and waste, interest on steam and electric plants and on real estate, insurance on engine and dynamo rooms and contents)	67.0
4. Cost at lamp or motor without depreciation (= Item 3 plus general salaries, office expenses, cost of carbons, globes, incidental expenses, incandescent lamps legal expenses, repairs lines, interest on investment in lines, taxes, wages of wiremen and wiring supplies)	82.7
5. Cost at lamp or motor with depreciation (= Item 4 plus depreciation at 5% per annum on all parts on which depreciation has not been already allowed)....	100.0

METHODS OF CLEARING AWAY RAILWAY WRECKS.

At the January meeting of the New York Railroad club, Mr. W. L. Derr, Division Superintendent of the New York, Lake Erie & Western R. R., read a paper on "Appliances and Methods for Clearing Up Railway Wrecks," which brought out an interesting discussion, and from which we abstract the following particulars: The general subject of wrecking train equipment and operations was discussed in our issues of June 7 and Oct. 11, 1894, in which articles particulars were given of the practice on several roads.

The derrick and derrick car are the most important part of the wrecking outfit, and hand derricks have been largely superseded by derrick cars or steam cranes. The Chicago, Burlington & Quincy R. R. uses a heavy 40-ft. derrick car having two masts, one operated as a derrick by hand gear, and the other having the rope led down through the floor and between the sills to the rear of the car, the end of the rope having a shackle by which it can be attached to a locomotive. All parts of the derrick and machinery should be designed with a high factor of safety, to withstand the impact due to sudden heavy shocks. The hoisting tackle should be of chain or wire rope for very heavy weights, and the best quality of pure manila rope for lighter weights. Only iron or steel tackle blocks should be used in lifting. A spring shock-arrester may be attached to the lower tackle block, consisting of a cylindrical case containing a heavy coiled spring carrying the hook bolt to which the load is attached. Steam wrecking machines should have sills of plate girders, I-beams or channels, sufficiently deep to give vertical stiffness, and well braced laterally. The frames for the machinery should be of heavy iron or of steel, with the bearings for the movable parts formed in them. The power should consist of at least one pair of reversible engines, coupled together, and the crane may be mounted on a turntable, the boiler, coal bunker and water tank forming the counterbalance to the boom. The machinery should have lifting, lowering and revolving motions, raising and lowering motions for the boom, and self-propelling gear, while provision should be made for revolving the crane in either direction without reversing the engines. Straight booms are usually of I-beams or channels, while curved booms are usually plate girders. To anchor the car while making a side lift, two or more outriggers are used, each consisting of a pair of I-beams, placed below the sills, and so fitted that they may be run out on either side, the outer ends being supported by jacks or blocking. Screw jacks to support the car frame, and rail clamps to hold the car down to the track are also provided. A steel wrecking car, now being built for the Norfolk & Western R. R., is 22 ft. long and 10 ft. wide, weighing 110,000 lbs. complete. The crane has a range of radius of 14 to 20 ft., and is designed to hoist 50,000 lbs., at 16 ft. radius, either in front or on either side, outriggers being used in the latter case. A useful addition to the machinery of a wrecking car would be a steam capstan (or vertical drum), as used on board ship. This device would be very handy for special hauls when the derrick is under load, and would thus replace specially-rigged hand tackle.

The tool and living car should have a tool room (with racks for ropes and tools and fixed clamps for jacks), kitchen, office and living room, with berths and table. Steam-heating pipes and a stove should be provided.

In the list of tools and appliances, hydraulic jacks are the most important, being second only to the derrick. A set should include jacks of 10 to 30 tons capacity, and, at least, one pair should be fitted with claws. They should have thumb-screw releases. The common wrecking frog consists of a heavy bent bar, the upper end of which is pivoted to a support which straddles the rail, the feet of this support and the free end of the bar having spurs to bite into the ties or blocking and prevent slipping under a load. With these are used wedges of wood, plated with metal, the "long wedge"

FUEL ECONOMY OF ELECTRIC LIGHTING STATIONS.

Engines—Class.	Water consumption per H.P.	Boilers—Class.	Evaporation per lb. of combus tible.	Equipment. Dynamos. Class.	Average amperes.	Average voltage.	Hours run.	Power. Total watts.	Revolutions every min ute.	Fuel. Total watts, all ele ctric.	Kind and grade.	Watts produced per lb. of coal.	Coal used in one day, lbs.	Production. Arc circuit. Average amperes.	Average voltage.	Hours run.	Total watts.	Incandescent. Average amperes.	Average voltage.	Hours run.	Total watts.
B & F	...	A & D	9.37	Multipolar	...	...	...	325,500	30	22,967,552	½ soft coal, ½ hard screenings.	262	89,358	10.0	8,145	24	1,954,800	7.670	124.9	24	22,967,672
B F	...	C	17	Con. and Bipol.	...	...	...	2,322,750	60	46,500,440	Hocking screenings.	180	46,500	10.0	2,387	13	5,896,081	224	1,140	24	6,125,640
B F	...	C	...	Multi. Alt., etc.	...	...	...	...	...	10,453,331	Run of mines, Alabama.	177	50,884	...	...	...	1,278	96.4	1,010	24	2,434,500
E	27½	C	...	Arc, Alt.	...	...	...	...	15	997,238	George's Creek, Cumberland.	182	5,460	6.8	47	4	120,000	37	1,100	15	67,064
B X	32.7	C	11.3	Alt. and Con.	...	...	23¼	1,125,765	15	640,100	Cumberland.	175	3,700	10.0	1,000	12	357,000	35	1,100	13	520,100
F	...	C	...	Alt. and Con.	...	...	10½	260,170	...	4,313,846	Pennsylvania soft coal.	174	24,750	6.7	7,000	8	355,144	7.05	1,172	24	1,983,024
B E Z	15.5	B	8.4	Arc,	...	...	...	588,743	60	10,532,752	6Soft coal.	170	62,000	9.5	48	14	10,532,752	...	...	...	...
		A	...	Various	...	...	...	548.2	10½	15,878,250	Slack and nut.	158	50 tons.	9¾	4,800	12	6,000,000	150	2,200	24	7,920,000
E X	24	C	10.5	Arc, Alt.	...	...	...	950,000	...	3,849,000	Michigan run of mines, poor.	108	35,322	by	Meter	14	246,000	...	Meter	24	380,000
O X	23	C	...	Various	...	...	...	...	...	845,333	Cumberland and hard screenings.	104	8,131	6.8	2,275	14	7,042,426	...	...	...	...
B F	23.6	B	11.34	Alt., Bipolar	...	...	24	400,000	...	16,704,000	Buckwheat, No. 1 and 2.	100	164,000	8.8	50	12	1,817,256	137	1,130	24	3,715,200
O X	...	A	...	Alt., Bipolar	...	...	...	948,000	...	5,241,500	Illinois lump and nut.	86	60,283	8.8	...	...	1,771,653	40	1,100	16½	837,930
B E	...	C	...	Alt., Bipolar	...	...	24	465,000	30	2,806,081	Second Young'y, nut.	83	21,203	6.8	...	7	357,000	40	1,200	14	672,000
F	...	C	...	Alt.	...	...	10½	100,000	60	1,029,000	Coaldale, bituminous.	128.6	8,000	6.8	1,100	5¾	43,010	27	1,100	7½	Meter.
					...	...	...	...	60	267,410	Pocahontas, Cumberland.	121	2,200								224,400
A Y	18	C	8.8	Alt., Bipolar.	...	...	24	950,000	...	3,849,000	Michigan run of mines, poor.	108	35,322	10.0	Meter	24	1,000,000	....	Meter	24	90,000
F	...	C	9.02	Various	...	...	...	...	...	845,333	Cumberland and hard screenings.	104	8,131	6.8	6,500	8½	367,333	100	240	16	384,000
A	...	A	...	Various	...	...	...	...	15	16,704,000	Buckwheat, No. 1 and 2.	100	164,000	...	...	...	...	6,000	116	24	...
					...	...	...	...	15	5,241,500	Illinois lump and nut.	86	60,283	10.0	3,472	24	833,250	330	116	24	3,823,000
F	...	A	7.68	Various	...	...	...	584,640	30	462,400	Second Young'y, nut.	83	1,983	6.8	1,152	7¼	56,940	24	1,040	24	105,599
F	...	C	...	Alt.	...	...	...	127,269	30	530,993	Indiana slack.	80	6,383	6.8	1,150	7¼	35,700	16.75	2,000	8	288,000
G X	...	A	...	Alt.	...	...	...	...	...	2,016,000	Illinois nut.	78	25,000	6.8	656¼	8	...	180	110.8	24	2,016,000
..	...	..	...	Con. and Multi.	...	...	...	500,856	..	6,008,850	Soft slack.	69	86,750	10.0	50	..	1,500,000	104	120	24	3,700,000
B E X	...	A	...	Various	...	...	...	181,035	30	1,640,000	Indiana block.	44	42,000	...	...	...	...	140	1,100	24	299,000
F	...	O	6.3	Various	...	...	223.5	181,035	30	2,700,565	Bituminous pea.	44	79,800	...	...	...	...	100	1,000	16	1,640,000
					...	...	...	...	...	...	Bituminous slack.	36	11,000	10.0	50 ca.	12	1,104,250	112	1,120	12	1,505,280

Equipment:
Class A. Boiler room: Horizontal water-tube boilers; feed through heaters by steam or power pump; hand firing. Engine room: Triple expansion condensing engines. Dynamo on engine shaft.
Class B. Boilers, vertical water-tube; economizers; feed as A. Hand firing. Engines, Corliss compound condensing, belted to jack shaft.
Class C. Boilers, horizontal tubular feed as A. Engines, simple Corliss or slow-speed, condensing. belted to jack shaft.
Class D. Boilers, upright tubular; feed as A; engines, simple Corliss, non-condensing.
Class E. Engine, high-speed compound condensing, belted direct.
Class F. Engines, high-speed simple, non-condensing, belted direct.
Class G. Engines, high-speed compound non-condensing.
Ref. X. Any of the above non-condensing.
Ref. Y. Belted to dynamo.
Ref. Z. Dynamo on the engine shaft.

being 6 ft. long, with both ends inclined, and the "short wedge" only 3 ft. long, with one end inclined. Various forms of wrecking props are used, being placed on or at the side of the rail. The paper contained a list of the equipment for a wrecking train, and suggested that the train should consist of a 35-ton steam derrick, a tool and living car, and a car for heavy tools, blocking, etc. The tools of each wrecking car should be painted or marked in a distinctive manner, and one man made responsible for their being returned and kept in place. The crew should include a wreck master, in general charge, an assistant wreck master, an engineman for the derrick, and 10 to 30 men, according to the size of the wreck.

Torches and other open lights are a source of danger, especially when there is oil or other highly inflammable material exposed. An electric arc light would add greatly to the convenience and safety of wrecking operations, and it was suggested that an electric searchlight, mounted on the derrick car, would be specially valuable, as its light could be turned to any desired part of the work. On the New York, Pennsylvania & Ohio R. R. a revolving headlight is located on the roof of the derrick car. Two sizes of oil torches are used, the larger ones mounted on wooden posts placed at convenient points, and the smaller ones being carried by hand. The Wells light is an excellent light for wrecking purposes, and is much used. Ordinary hand lanterns are used in working around inflammable wreckage. Where oil is exposed, as in the case of wrecked tank cars, it should be covered with earth or cinders before any work is done around it and before a locomotive or steam derrick is allowed to approach closely. If this cannot be done, a number of empty cars should be coupled between the locomotive and the derrick car, so as to keep the former at a safe distance.

In regard to the care and transportation of injured persons, an ordinary car is better than a parlor car, owing to the winding entrance of the latter. Stretchers should be about 7 ft. 3 ins. long and 21 ins. wide. The stretchers may be placed across two reversed seat backs, which gives them about the right height for convenient medical attention. In case of cattle train wrecks, the uninjured stock should be transferred promptly, and badly injured cattle must usually be killed on the spot. With refrigerator cars, special care should be taken to replace the ice and put scattered freight back in one of the least injured cars.

The quickest way of notifying the wrecking gang is by means of electric bells connecting the despatcher's office with the shops where the men usually work, the men starting for the wrecking train as soon as they hear the bell. Whistle signals may also be given. The despatcher's office may also have connection with bells in the houses of some of the men, so that they can be notified at night, these men being assigned the duty of calling others in the neighborhood.

The most important part of the discussion related to the organization of the wrecking gang. Mr. Wattson said that on the New York, West Shore & Buffalo R. R. the clearing of wrecks is in charge of the roadmaster. The motive power department furnishes four men, one of whom is called the wreck master, and he has charge of the three mechanics sent with him and of the handling of the equipment on the wrecking train. If the wreck is a large one, the master mechanic is asked to send with the train as many additional shop men as may seem necessary. After the wrecking train is at the point of action, its operation is in charge of the roadmaster, who has collected as many of his foremen and sectionmen as necessary, and either the superintendent or trainmaster is present to assist the roadmaster, but only to assist, as it is believed that only one person at a time can successfully direct the work. There is always an abundance of ideas as to how the work should be done, and if a chance were given to try them all the road might remain blocked indefinitely. Every freight train is furnished with a set of Tilden wrecking frogs.

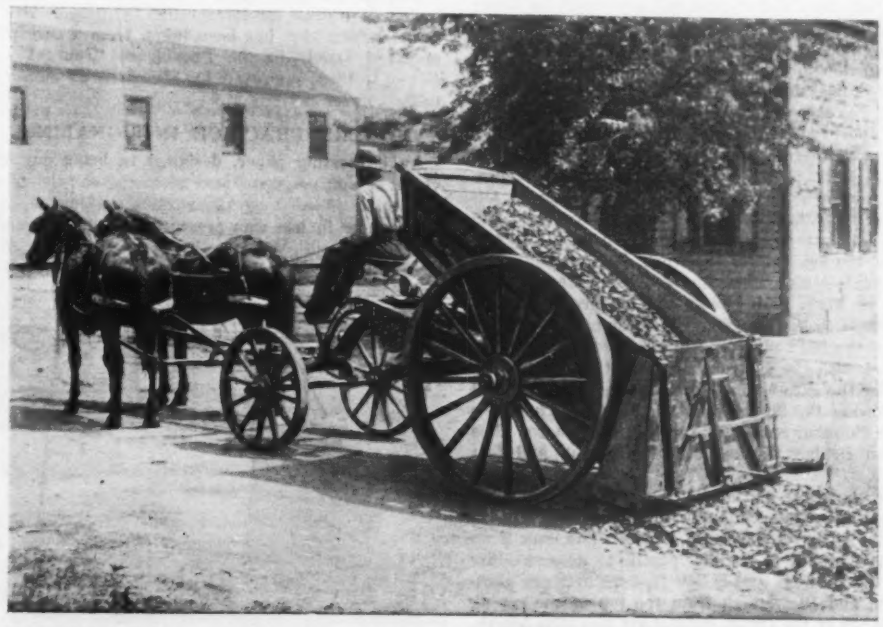
Mr. Lewis said that on the Delaware, Lackawanna & Western R. R. the wrecking master keeps four men with him all the time at Hoboken, doing odd jobs about the roundhouse. About ten men form the gang, and the other six work at the shops, which are seven or eight miles up the road. A double-end wrecking car is used, but the chief reliance is placed upon jacks.

Mr. R. C. Blackall said that on the Delaware & Hudson R. R. a special box car, with boom, is used, instead of a derrick car. The boom is carried inside the car and put up on whichever side it is needed, the pulling being done by a locomotive and wire cable. With this car a freight car can be picked up bodily, trucks and all. He favored the plan of having the roadmaster in charge of clearing wrecks.

Mr. Derr said that on his division of the New York, Lake Erie & Western R. R. the wrecking outfit consists of a hand derrick and a steam derrick car of 25 tons capacity. For heavy work about 16 men are employed, 2 foremen and 14 men under them, but for ordinary wrecks of two or three cars not more than 10 or 12 men are employed. With very bad wrecks, one division gets the wrecking gang from the next division. On this road the wrecking organization is under the superintendent of motive power, and the men are taken from among the car repairers. The maintenance of way and transportation departments do the work. He has had experience of wrecking work with the roadmaster's force and the shop force, and thinks the latter better qualified, because of their familiarity with jacks and machinery, while the same men can always be had for the work, so that they become familiar with it. Every baggage car is furnished with an ordinary frog and wedge, and with the necessary chains for doing light wrecking. Jacks are kept at all important telegraph stations. The tools of each wrecking car are marked, and the car is not allowed to leave the wreck until the complete equipment is returned or accounted for.

THE CHAMPION STONE-SPREADING CART.

The "good roads" movement has had an important influence in stimulating the design of improved machinery and appliances for road work, and the accompanying illustration represents a cart specially designed for distributing broken stone for building or repairing roads. The cart is mounted on four wheels, so arranged that it can be turned in a short space. The bottom of the cart slopes downward to the back and the tail board is hinged at its upper edge, the movement of the lower edge, and consequent width of opening, being controlled by two adjusting chains, while steel wings are attached at the sides of the cart at the tail board so as to spread the stone the full width between the wheels. The cart is tilted by a rack and pinion operated by a crank and gearing, and may be held at any desired angle, which is a great convenience in loading by hand. As the stone flows from the rear of the cart it is leveled by means of a scraper attached to the bottom of the tail board, this scraper being pivoted at the center and made adjustable at either end by means of a horizontal lever at the back of the tailboard. This adjustment enables the stone to be spread thicker on one side than on the other, thus giving the road an extra thickness of stone at the middle, as is usually required. It also enables the stone to be spread on a strip only half as wide as the cart. For a roadway 12 ft. wide two side strips each 5 ft. wide can be laid, and then the 2-ft. middle strip can be laid by adjusting the scraper.



THE CHAMPION DISTRIBUTING CART FOR ROAD CONSTRUCTION AND REPAIRS

The front wheels track inside the rear wheels, and the cart is fitted with a good lever brake. The carts are built in two sizes, to be hauled by two or three horses, respectively, the horses being harnessed abreast. The smaller (two-horse) size is 5 ft. wide, has a capacity for 1½ cu. yds. of stone, and weighs 2,250 lbs. when empty. The front wheels are 3 ft. diameter and 3-ins. wide, on a 2-in. axle; and the rear wheels are 5 ft. diameter, 5 ins. wide, tread 5 ft. apart on a 2½-in. axle. The larger (three-horse) size is 7 ft. 6 ins. wide, has a capacity of 2½ cu. yds. of stone and weighs 2,750 lbs. empty. The rear wheels are 5 ft. diameter, 6 ins. wide, and mounted on a 3-in. axle. By the use of wide tires and the arrangement of the gage of the wheels the width of bearing surface is 16 ins. for the smaller and 18 ins. for the larger carts. The cart body is built of white oak, with hickory floor and sides, and malleable castings are used for the fittings. The cut shows the cart in position for distributing stone, the body being tilted and the tailboard open. These carts are manufactured by the American Road Machine Co., of Kennett Square, Pa.

AN IMPORTANT PATENT DECISION IN THE BATE REFRIGERATING CO. CASE.

An American patent expires with the earliest foreign similar patent, regardless of date of application, according to the late decision of Justice Harlan, of the U. S. Supreme Court, in the case of the Bate Refrigerating Co. vs. Sulzberger et al. On Dec. 1, 1876, Bate made application to the United States for letters patent on a process for preserving meat during storage and transportation. But previous to the granting of the American patent, two foreign patents had been issued for the Bate process; one for 14 years by the British Government to Wm. Robert Blake, sealed July 13, 1877, and one for five years of the Dominion of Canada, issued to Bate himself on July 9, 1877. On Nov. 20, 1877, Bate received a U. S. patent for the term of 17 years, and assigned it to the Bate Refrigerating Co. The present suit was brought on July 25, 1892, for an injunction against the infringement of the U. S. patent, and also for an accounting. Both foreign patents having expired before the expiration of the 17 years of the American patent, the question arose whether the invention for which the American patent was issued had

been "previously patented in a foreign country," within the meaning of these words in Sec. 4887 of the Revised Statutes, and whether the American patent expired under the terms of that section before the expiration of 17 years from its date.

The plaintiff insisted that as long as the application was made for the American patent before foreign patents were issued, the term of the American patent should hold good. The defendants contended that the respective dates of the American and foreign patents, and not the date of the American application, should determine the question whether the invention had been "previously patented in a foreign country."

Justice Harlan reviewed the several acts of Congress from 1790, and decides that the statutes relating to patents always had in mind the difference between an application for a patent and a patent itself; and the express command of the existing statute is that every American patent for an invention "previously patented in a foreign country," or "first patented or caused to be patented in a foreign country," shall expire at the same time as the foreign patent. The statutes contain no exemption from this command. The intent of the American patent law and the Acts of Congress is to fully protect American inventors, and these laws prescribe methods for reaping the benefits of foreign patents. But the American patent is granted on the condition that if a foreign patent is first obtained, the invention shall be free to the American people as soon as it is free to foreigners by reason of the expiration of the foreign patent.

NEW MASONRY DAM AT LONSDALE, R. I.

An unusual combination of a dam and railway bridge across the Blackstone River at Lonsdale, R. I., was completed recently for the Lonsdale Co., which has extensive mills at that place. Reference to the accompanying plan, Fig. 1, will show the location of the old dam, built some 50 years ago, and of the old railway track, carried across the river on a pile trestle. The new dam was located and constructed as shown in the accompanying illustrations, in order that the operations of the company depending upon the old dam and railway might be interfered with as little as possible. In addition, the use of the old dam while the new one was under construction obviated the necessity of expensive coffer dams. Mr. John W. Ellis, of Woonsocket, R. I., was the engineer for this work, and his plans were approved by the late Mr. Jas. B. Francis.

The contract for the stone required was let on Dec. 3, 1892, to Mr. John T. Tank, of Providence, R. I., owner of quarries in Northbridge, Mass. On Feb. 21, 1893, Mr. Tank contracted to build the dam and gate chamber. The Lonsdale Co. furnished the cement for the work, buying Hoffman's Rosendale cement from the Lawrence Cement Co., of New York, and Alsen's Portland cement, from Waldo Bros., of Boston. The company also furnished the hard pine used in construction, and contracted with the Holyoke Machine Co., of Worcester, for the gate chamber gearing and that required for raising the 30 sets of flash boards. The gates in the chamber were built by the Lonsdale Co. The Boston Bridge Works built the railway and foot bridge.

The character of the dam is shown by the plan, Fig. 1; the cross-section, with dimensions, Fig. 2; and the two views, Figs. 3 and 4. The dam is on a curve of 700-ft. radius, partly to accommodate it to the railway, and is 349 ft. long between abutments, and 12 ft. high from the top of the coping to the top of the apron, throughout its entire length. The five piers support six 54-ft. plate girder spans, while the gate chamber opening is a half-through lattice girder 80 ft. in length. The approaches to the bridge were carefully constructed, and the bridge is calculated to carry heavy locomotives of the New York, New Haven & Hartford R. R. Co., which operates the line. The railway is owned by the Lonsdale Co., and connects its works located on both sides of the river.

The two lines of sheeting shown on the plan and in the section, Figs. 1 and 2, are driven from 20 to 30 ft. deep, and are grooved and splined. The face of the dam is of cut granite, and this is backed with rubble. The spikes used in the timber apron shown in Fig. 2 are 1⅝-in. galvanized iron 16 ins. long, and the down-stream sill is fastened to the sheeting by ½-in. galvanized iron spikes 12 ins. long.

Work was begun by Mr. Tank on April 9, 1893. From May 5 to 9 and from May 17 to 22 high water stopped the work, but there was no more trouble from this cause during the construction of the gate chamber, which was filled on Nov. 25, 1893. Work on the west end and abutment of the dam was begun early in July and continued until

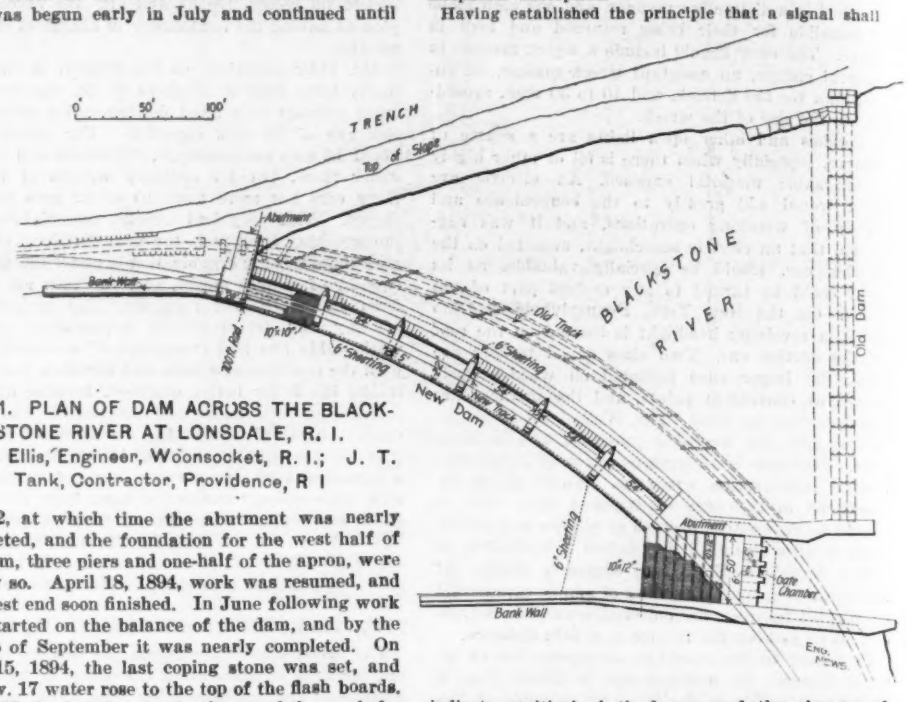


FIG. 1. PLAN OF DAM ACROSS THE BLACKSTONE RIVER AT LONSDALE, R. I.
J. W. Ellis, Engineer, Woonsocket, R. I.; J. T. Tank, Contractor, Providence, R I

Dec. 2, at which time the abutment was nearly completed, and the foundation for the west half of the dam, three piers and one-half of the apron, were wholly so. April 18, 1894, work was resumed, and the west end soon finished. In June following work was started on the balance of the dam, and by the middle of September it was nearly completed. On Nov. 15, 1894, the last coping stone was set, and on Nov. 17 water rose to the top of the flash boards.

Mr. H. L. Quimby was in charge of the work for the contractor. The resident engineer under Mr. Ellis was Mr. L. W. Tucker. We are indebted to Mr. Ellis for the drawings and photographs from which the accompanying illustrations were made, and to Mr. Tank for information furnished. Additional information has been taken from a carefully prepared article in the Providence "Journal" of Feb. 11, 1895, approved by Mr. Ellis as substantially correct.

MODERN PRACTICE IN SIGNALING.

An interesting paper, designed to bring out the views of motive power men as to the sufficiency of protection afforded by the various systems of signaling now in use was presented at the February meeting of the Western Railway Club, by Mr. George Gibbs, M. Am. Soc. M. E., Mechanical En-

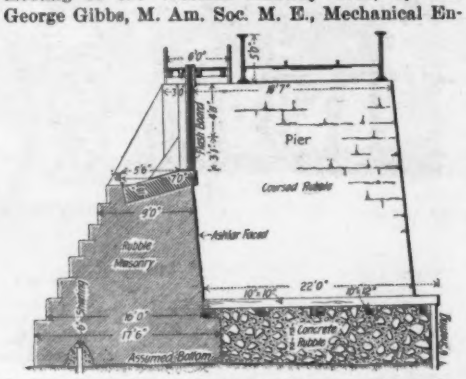


Fig. 2. Cross Section of Lonsdale Dam.

gineer of the Chicago, Milwaukee & St. Paul R. R., and will be taken up for discussion at the March meeting of the Club. The following is an abstract of the principal points brought out in this paper:

It is only very recently that substantial accord has been reached among operating men that when a signal is established at a danger point this signal must indicate the absence of danger as well as its presence. This question being settled, the point arises how to convey the desired information to the engineman unmistakably at all times. With this, more difficulty is met, and many opposing views are held by those equally well informed. The medium through which the engineman receives the information is by his sense of sight; this acts through impressions of form, position and color. These impressions must be made to convey a variety of different meanings, must be clearly distinguishable in all conditions of weather and light, and must be read instantly without confusion. The attributes of an object most readily distinguished, and most invariably, are its form and position. Color is a more complicated impression, and one less to be relied upon, being modified by reflection and by atmospheric absorption.

Having established the principle that a signal shall indicate positively both danger and the absence of same, and that it shall do this by form and position, rather than by color, we arrive at the device considered by progressive minds to be the best offered up to date for the purpose, that of the movable semaphore arm. In using the "position" signal we meet with a serious difficulty in carrying out the principle for a night signal; so much so, in fact, that the attempt has been temporarily abandoned for the use of color only. We have thus (standard at the present time), a position day and a color night signal, both intended to convey the same indication. The real fault with the colored light for night signals is in its confusion with other lights not intended for signals, and limited scope of the possible code. In explaining the seriousness of these objections, it is necessary to state here what information we desire to convey in directing train movements.

Fixed signals are established (1) for showing the condition of the track, that is, position of switches, connections, etc.; (2) for showing the location of other trains, or for directing train movements. Of the first class, we have switch, railway crossing and drawbridge interlockings; of the second, train order and block signals. For both classes we must further divide the indications into "all clear," "danger," "cautionary," and "route" signals. Now, in daytime, these various instructions may be clearly defined by shape, color and relative locations of the signal blades. At night, this must be done by colored lights alone. If we leave out of consideration for the moment the differentiation of the two main classes of signals, viz., track and train movement, we have still three absolutely distinct indications desired to be made by colored lights; one for "danger," stop; one for "caution," move under control; one for "safety," proceed. American practice in the past has largely tended toward the following code of lights: Red, danger; green, caution; white, clear. The leaning of the committee appears now to be towards red, for "danger"; green, for "safety"; combination of green and red, for "caution." This system has been used for some years upon the Chicago & Northwestern Ry., to their satisfaction, I am told. It does not appear to be a wholly satisfactory solution of the problem, for these reasons: First, red and green are lights of different strength, which makes the indication uncertain at a distance; second, it is possible for two separate signals to be so placed that a danger (red) in one and a clear (green) in the other might be mistaken by enginemen to be a "combination cautionary" signal, thus causing him to slow up only, when he should stop.

Seeing that no code yet proposed is wholly free from objection, it is necessary to weigh the disad-

vantages of each and come to a decision justified by facts and experience. It appears to me that the following is the best solution to date for a night signal code: Red light, danger, stop; green light, clear, proceed; combination red and green from one lamp, caution, go slow.

For the day code we have at our command color, form and position. The indications wanted are: (1), to show to what system the signal belongs, whether

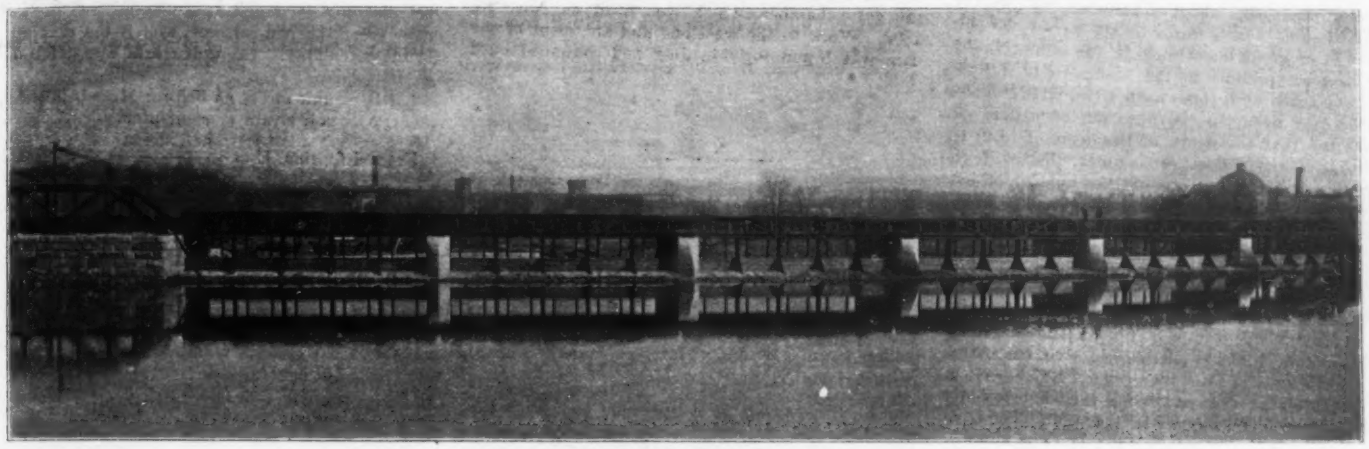


FIG. 3. UP-STREAM VIEW OF LONSDALE DAM.

switch, block or train order; (2), to show the varying conditions under these systems.

Usual practice establishes the following standard forms of semaphores; (1) "Home" signals, that is, signals at or very near the danger point, have blades cut square at the end and painted red. These govern the position of a block interchangeably, and assume but two positions; horizontal (and red light at night), "danger"; nearly vertical (and white light—or green, under new code—at night), "clear." (2) "Advance" signals, same form and indications as "home." (3) "Distant," or cautionary, signal arm cut with a fish-tail end and painted green. These have also two indications; horizontal (green—or, under new code, combination—light at night), caution, proceed, expecting to find "home" signal at danger; inclined (white light at night), clear.

Different routes are signaled by separate arms, either on same or different posts. An important point to be

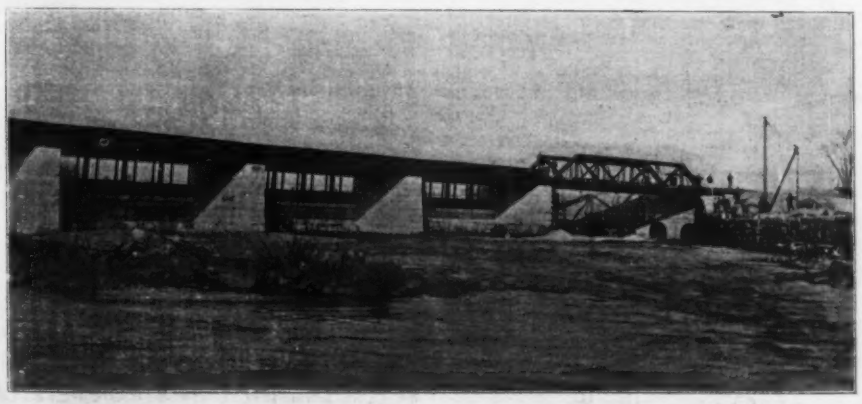


FIG. 4. DOWN-STREAM VIEW OF EAST HALF OF LONSDALE DAM AND OF GATE CHAMBER.

remembered is that an arm has significance in one direction only, governing an approaching train from which it appears pointing from the right of the mast.

The paper then continues with descriptions of the various signal systems now in use. These are divided into (1) systems for showing the conditions of the track, that is, providing safety where switch movements are to be made, under which are included (a) switch signals, (b) switch interlocking, (c) crossing, junction and swing bridge interlocking; and (2) systems for directing train movements, under which come (a) train order, (b) telegraphic manual block, (c) controlled manual block, (d) automatic block, and (e) mechanical block. These various systems are familiar to most railway mechanical men, and we do not reprint the descriptions given in the paper. The paper continues:

Systems of switch control present few points of comment. Both the mechanical and electro-pneumatic interlockings have proven perfectly reliable, especially when provided with an electric track circuit, locking the lever to prevent the operator from changing a combination, when once given, until the train has passed over the danger point.

Considering block systems, the old system of despatching by train orders is likely to pass rapidly out of use when the superior advantages of an ordinary manual block are more fully understood. It has been only during the past three or four years that the block system has been thoroughly demonstrated to be a success upon heavily worked single-track main lines. The C., M. & St. P. has without doubt done more than any other railway in the country to prove the success of this system. It has at present 1,270 miles of single-track blocks in operation, and finds the traffic handled with equal expedition and much greater freedom from accident than under the "order" system.

The weak point of the manual system lies in the fact that safety depends entirely upon each operator individually. If any one operator should fail to report the location of trains correctly, should misinterpret orders, or should fail to display his signal correctly, an accident is possible—and even probable. These circumstances have been of sufficient frequency to lead to a great amount of ingenuity in devising manual-controlled systems. In these the simultaneous failure of two operators is necessary to allow more than one train in the block at the same time. The "theory of probabilities" would indicate that this should cut down enormously the chances of accident. Of course, it is necessary in all these systems to take for granted that the engineman will see and obey these signals.

The manual-controlled, sometimes called the "Sykes," system, with the addition of the track circuit releasing sections, provides a very complete measure of protection on double-track roads (it is not applicable to single track), and would be wellnigh perfect, were it not for the practice of "permissive" blocking. This practice means the breaking down of the space for the time interval between trains. Its definition is "allowing two trains in the block at the same time, the second following the first under cautionary signal." It is primarily necessary, from reasons of economy, which dictates that block stations shall be relatively far apart, to save expense of installation and operation. In places of dense traffic, therefore, it is sometimes necessary to use the "permissive" to avoid delays. The practice is wholly bad and dangerous, and warrants considerable expense, where traffic is at all dense, in abolishing its necessity.

There is another cause for the use of permissive blocking, which does not always admit of being done away with at reasonable cost, and that is switching at factory and other sidings. The English practice of interlocking all sidings with the block system necessitates establishing stations at or near all such points, which is, of course, impracticable in a thinly-settled country. The purely automatic system allows us to provide a much greater measure of safety under such conditions, and at a slight additional operating cost. This may be done by erecting additional automatic signals at each side of the factory switches and interlocking the switches with these signals, thus making short intermediate blocks. In fact, under this system, we should entirely obviate the necessity of permissive blocking by making the block sections short enough. The great objections to automatic systems are (1) cost of installation; (2) liability of getting out of order. As to cost, this is a question which must be figured out for each case; in many instances it is a simple matter to show a large interest earned upon the additional cost over the plain manual system, by saving in operating expenses of the automatic.

As to liability of getting out of order, this is a serious objection to all automatic devices, but it is not necessarily an inherent one. The difficulty arises from the general impression that an automatic device is one which takes care of itself. Nothing could be farther from the truth; an automatic device operates without human intervention, but requires care in proportion to its complexity and the character of the service demanded of it. If the amount of care needed is burdensome, then the device is unsuitable, otherwise not. Automatic signal systems can, I think, be kept in reliable working order with a very reasonable amount of care.

I should say here that, in case of failure of any part of automatic signal apparatus, such as breaking of track circuit, or other wires, running down of batteries, etc., the result is to set the signal at danger, the cardinal principle of all signaling devices being that no failure of parts shall, under any circumstances, allow the signal to indicate safety. Thus, in case of breakage of parts, the train will be stopped, unnecessarily by red signal, which may be said to err on the side of safety. Such stoppages are, however, quite objectionable if they occur at all often, as, aside from the delay to traffic caused thereby, they are apt to weaken the confidence of the engineman in the reliability of the devices, and cause him to attach less importance to a "stop" signal.

DEPTH OF SAND IN FILTER BEDS NECESSARY TO REMOVE BACTERIA.

By Grace C. Frankland.*

Although it sounds like a truism to state that sand filtration, when efficiently pursued, offers a very remarkable barrier to the passage of bacteria in water, yet the factors upon which that efficiency depends have not yet been so thoroughly mastered as to be reduced to a condition of servitude. We have no acknowledged law of filtration, although we have, no doubt, a very shrewd notion of what is right or wrong. Already, in 1886, Dr. Percy Frankland pointed out** some of the factors which he had

* Joint author with Prof. Percy Frankland, St. Andrews' University, Dundee, Scotland, of "Micro-Organisms in Water."

** Water Purification; Its Biological and Chemical Basis. Trans. Inst. C. E., pp. 197-263, including discussion.

found were of importance in the processes of sand filtration, as carried out by the London water companies, and amongst these he emphasized the importance of the thickness of fine sand through which the water percolated. Later researches have fully confirmed these results, and this is especially brought out by Dr. Reinsch, in his recent investigations, just published, on the filtration of the Altona water. Reinsch, whilst acknowledging that the layer of slime which forms on the surface of sand filters is of great importance in the elimination of the bacteria present in the water to be filtered, does not agree with those authorities who regard it as the only agent in the filtration of water. He points out that the depth of the layer of sand operates in a most important manner; that with the reduction in the depth of sand the number of bacteria in the filtrate regularly increased. To test this point in more detail, he drew off the water as it passed through the sandbed at various depths, commencing immediately beneath the layer of slime at depths varying from 60 to 920 mm. (2.36 to 36.22 ins.). One example is sufficient to indicate the nature of the results obtained: The untreated water contained 36,320 microbes in 1 cu. cm. After passing the layer of slime there were 1,876 per cu. cm. found, whilst after traversing the whole column of sand there were only 44 in 1 cu. cm. Thus, although after passing through the layer of slime a very large reduction is effected in the microbes present, yet the filtrate still contains bacteria in numbers altogether inadmissible in a properly filtered water. These results are of importance, as there is a tendency at the present time to attribute too exclusive an importance to the slime and ignore the depth of sand material. Reinsch does not mention the investigations made during the past few years at the Zurich water-works, where it was also found that to reduce the depth of sand was to damage the filtrate, and that, in consequence, the layer of sand should never be allowed to sink below 30 cm. (practically 1 ft.) Reinsch, in his conclusions, states that the column of sand, to produce a good filtrate, should never be less than from 40 to 60 cm. (15 to 24 ins.) deep. In order to encourage the formation of surface slime, the filters at Altona, after the water is run on, are left undisturbed for twelve hours, and Reinsch states that the neglect of this simple precaution exercised an important influence on the filtrate. These investigations were carried on at the Altona water-works over a period of 18 months, during which time daily samples were bacteriologically examined from each individual filter-bed. In this manner the working of each filter was under constant surveillance, and any abnormally high numbers in the microbes present in any filtrate was at once noted and its cause investigated, thus enabling a bad filtrate to be at once rejected before the whole supply had become deteriorated or endangered by its admixture.

It will be remembered that Koch ascribed a recrudescence of cholera in Altona during the great epidemic to the inefficient working of one of the sand filters, the imperfections in which were not discovered until the whole water supply had become infected. Reinsch points out how essential it is that, in the construction of filter beds, due regard should be had to the possibility of taking satisfactory samples for examination, which in the beds of older construction is often a matter of extreme difficulty. This point is also of importance in the opportunity it offers for the accumulation of facts which will ultimately afford material for the building up of a rational system of filtration which will be of the greatest service in the efficient purification of water.

TRANSVERSE STRENGTH OF DOUGLAS FIR.

By Chas. B. Wing, Professor of Structural Engineering, Leland Stanford University.

The increasing use of the Douglas Fir timber of the Pacific Coast states in engineering construction makes any information regarding its strength of especial interest at this time, and the accompanying diagram shows graphically the results of a number of transverse tests of this timber recently made at the Leland Stanford University. These tesst were made by the writer and Mr. R. M. Drake, one of the students of the University, and comprised the breaking of ten 6 × 10-in. × 17-ft. beams, and ten 3 × 5-in. × 4½-ft. beams cut from the broken 6 × 10-in. × 17-ft. timbers first tested. A sketch of the apparatus used in testing the larger beams is given in Fig. 1, and in Fig. 2 are shown by diagram, the unit stress and unit strain in the outer fiber in pounds per square inch, strain here meaning the deformation resulting from the stress.

The larger, or 6 × 10-in. × 17-ft., beams were

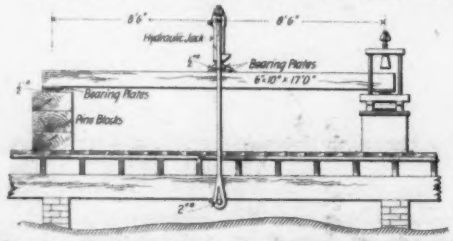


Fig. 1. Apparatus Used for Testing Douglas Fir Beams 6 x 10 ins. x 17 ft. at Leland Stanford University.

broken transversely by a hydraulic jack of 10 tons capacity, and the reaction measured by the scale platform of a 20,000-lb. Olsen testing machine, as shown in Fig. 1. After the original timbers were broken the remaining solid timber was cut into the smaller size test specimens and broken directly by the testing machine. In all cases the pressure was applied against the edge or narrower side of the beam.

The method used in measuring the deflections of the specimens was essentially the same as that used by Professor J. B. Johnson, of Washington University, St. Louis, Mo., in testing yellow pine for the government timber tests. A nail was driven into the side of the specimen at each end, and in the middle of its height, and a fine silk thread passed over the nails and weights attached to each end. These weights were for the purpose of taking up the slack in the thread which was caused by the shortening of the specimen due to its deflection, and for keeping the thread uniformly tight. The deflections were measured on a scale attached to a mirror, which, in turn, was attached to the middle of the specimen by a piece of putty. In reading the scale, the image of the thread in the mirror was made to coincide with the thread as seen by the eye directly. This insured the same position for the eye at each reading of the scale. None of the specimens were selected for testing. The timber was ordered from a San Francisco lumber yard, and would probably rate as a poor lot of No. 1 merchantable. Some of the sticks failed by shearing along the fiber parallel to the length of the specimen. These have been noted, and the shearing strength of the timber, as shown by these tests, has been computed. It was noted that knots, even when sound and tight, weakened the stick by decreasing the section and by causing the fiber to be cross-grained and curly, easily crushing when in compression. In the diagrams the unit strains are plotted as abscissae, and the unit stresses as ordinates. The unit stress was found by the well-known formula, $\frac{M\,c}{I} = S$, where M is the bending moment at the center, I the moment of inertia of the cross-section, c the distance of the outer fiber from the neutral axis, and S the unit stress in the outer fiber. The unit strain was determined as follows:

Let S = unit stress as before; M = bending moment; e = unit strain or elongation.

From definition, $E = \frac{\text{unit stress}}{\text{unit strain}} = \frac{S}{e}$ = modulus of elasticity.

Let l = length of specimen between supports, then, $M = \frac{P\,l}{4}$, where P = the single concentrated load at the center. Let D = the deflection determined by experiment. Then by substituting in the equations $S = \frac{M\,c}{I}$, the value of S from the equation $E = \frac{S}{e}$, we have, $E\,e = \frac{M\,c}{I}$, or $e = \frac{M\,c}{E\,I} = \frac{P\,l\,c}{4\,E\,I}$.

The theory of flexure gives for the deflection of a beam under a single concentrated load, $D = \frac{1}{48}\,\frac{P\,l^3}{E\,I}$. Dividing the above equation for e by this, we have, $\frac{e}{D} = \frac{12\,c}{l^2}$, or $e = \frac{12\,c}{l^2}\,D$.

The curves shown in the diagram are plotted from the values of e and S determined by the above formulas. Curves plotted in this way should show similar or comparable results independent of the size of the test specimen.

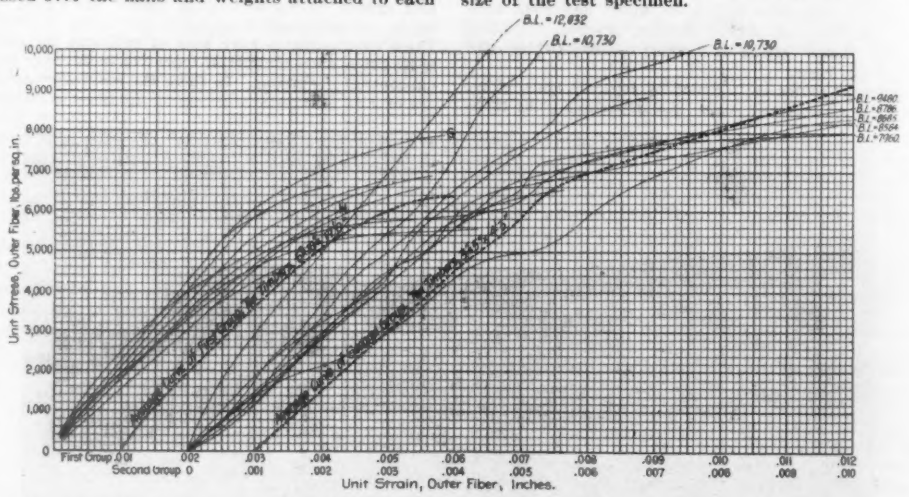


FIG. 2. DIAGRAM SHOWING ULTIMATE UNIT STRESS AND THE UNIT STRAIN DEVELOPED IN TRANSVERSE TESTS OF DOUGLAS FIR BEAMS AT LELAND STANFORD UNIVERSITY.

Sticks G and H, of the full-sized specimens, failed by shearing. According to the theory * of the distribution of shearing stresses in flexure, in surfaces parallel to the neutral surface, the intensity of shearing stress per unit of area at any point is a maximum in the plane of the neutral axis, and for rectangular cross sections is expressed by the formula: $X = \frac{3}{2}\,\frac{J}{b\,h}$, where X = shearing stress per unit of area in the plane of the neutral axis, J = the total vertical shear at the point in question; b = the breadth of the beam; h = the height of the beam.

With a single concentrated load, the vertical shear, at all points between the end of the beam and the load, is equal to the end reaction, and is constant throughout the length of the beam when the load is at the center. The end reaction at the

*Church, "Mechanics of Engineering," p. 284 et seq.

time of breaking was for stick G, 7,410 lbs., and for H, 5,725 lbs., and the value of the shearing stress computed by the above formula, 183 lbs. per sq. in., and 143 lbs. per sq. in., respectively. From these results it would seem that the danger of failure by shearing should not be lost sight of in using large timber beams in flexure.

The average shearing stress for nine of the full-sized beams at the time of breaking was 160 lbs. per sq. in. The modulus of shearing determined by these experiments is, therefore, not less than this amount. That it may be somewhere near it is indicated by the fact that two of the specimens broke by shearing longitudinally parallel to the fiber in the plane of the neutral axis, or nearly so.

THE USE OF CHEAP LOCAL MATERIALS FOR IMPROVING COUNTRY ROADS.

In the discussions on good roads and road improvements which have formed a part of the "good roads" movement, it has unfortunately too often been assumed that the aim in every case must be to obtain a macadamized road. In districts where stone is scarce and traffic light, the cost of such roads would be practically prohibitive, and although the existing roads may sadly need improvement, the people are not disposed to regard with favor any movement which would involve them in large expense for stone roads. This view of the matter was presented in our issue of Nov. 30, 1893, and it is encouraging to find that one of the bulletins issued by the Road Enquiry Bureau of the Department of Agriculture, of which bureau Gen. Roy Stone is the engineer, deals with the best method of constructing a common highway without gravel or stone, and contains references to the use of clay, sand, oyster shells, sawdust, etc., in various localities. The bulletin first gives the paper on "Dirt Roads," by Mr. J. H. Striedinger and Mr. O. Von Geldern, published in our issue of Nov. 16, 1893, in which paper the construction of corduroy or timber roads and roads across swamps was also referred to. It then gives particulars of the use and treatment of some special classes of material, which we abstract below, and it will be noted that the importance of proper drainage is emphasized in three or four cases:

In describing the construction of cheap, well-kept earth roads in Virginia, Capt. O. A. Browne, of Cape Charles, Va., says that the soil of that locality is fortunately so mixed with sand and clay that it forms a very good roadbed, and a little sand on the top of it makes a lasting cushion to take the wear of travel, and when the water is properly drained off, an excellent cheap country road is the result.

When the soil has too much clay, it is easily corrected with sand, and it is surprising how little it takes; the reverse of this treatment is also a success. When the proper combination is made, the road becomes hard and lasting; so hard, indeed, that when necessary to work it up a Babcock hardpan plow must be used. This implement weighs 230 lbs., and breaks a width of 2 ins., and so hard is this mixture of clay and sand that it requires six mules, weighing 1,200 lbs, each, to pull the plow when running 6 ins. deep. The hardpan plow is first used to loosen the soil, six mules being attached; and this is followed by a farm turning plow, with two mules hitched to it. When sufficient ground is loosened, the team of six mules is put to the grader, and the two mules are hitched to an iron farm roller. The latter is kept on the center of the road all the time; the road is by this means rounded up, smoothed, and made as hard as this roller will make it. When the wheels cut down in the soil, the ruts are filled with oyster shells, and as these work down, clay, shells, and sand are put in the furrows, and by this means a good hard face is made in the road for the wheels to roll on. These roads can be made for $100 per mile.

Dr. Hardey, of Chataignier, La., gives the following method for constructing a road in the muddy part of Louisiana. Take common hay, rice straw, or, best of all, bagasse (mashed sugar cane), cover the muddy holes plentifully with it, and trample it down thoroughly. Cover this with dirt or mud, then roll it flat, and upon this bed place small poles or brush. Cover this with dry dirt or gravel, trample and roll it down thoroughly, then make a good, wide ditch to drain the road on both sides, and finally roll the surface of the road to make it slope toward the ditches. A road carefully and properly made in this manner will last 25 years with but little repair, if the drainage is maintained, and slight ruts or holes repaired at once.

Mr. Curtis C. Turner, of Omaha, Neb., says that road scrapers, drawn by eight horses, are largely used in that county, and have given very great satisfaction when properly handled, but that better results could be secured if heavy rollers were used in conjunction with them, and that more care should be used in removing sods and decayed vegetable matter from the roadway.

The farmers of Newcomb Township, Ill., have done much toward building good dirt roads, draining them with tile and with open side ditches, and keeping them carefully rounded up in the center. They tried the experiment of working a grading machine on them by the use of a traction engine, such as is employed for hauling thrashing machines around the country, and the trial was so successful that the engine was employed again next season for the same work. The expense is only $8 a day, including fuel, water, and two men, and the result is said to show that the work can be done more satisfactorily and rapidly, and at far less expense, than by the use of men and teams.

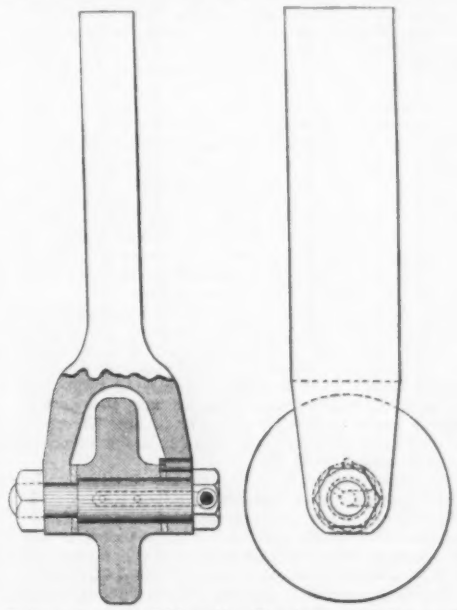
In regard to sandy roads, the usual way of improving such roads is to cover the surface with clay, or to mix the clay with the surface sand, but the Massachusetts Highway Commission says it is questionable whether this method of treatment is in the long run economical. The commission estimates the average cost of doing this at 15 cts. per sq. yd., with renewal in about five years, or 3 cts. per sq. yd. annually. It also estimates that a good macadam road can be constructed for 60 cts. per sq. yd., and taking into consideration the small amount of travel, and that the road is estimated to last 20 years, with hardly any repairs, the annual cost will be 3 cts. per sq. yd., or the same in each case.

Other materials have been used for the more or less temporary hardening of sand roads, and some of them with marked sucess. For this purpose any strong fibrous substance, and especially one which holds moisture, such as the refuse of sugar cane or sorghum, and even common straw, flax, or swamp grass will be useful. Spent tan is of some service, and wood fiber in any form is excellent. The best is the fibrous sawdust made in sawing shingles by those machines which cut into the side of the block. This has been used to some extent in portions of Wisconsin, and Mr. J. T. Kingston, of Necedah, Wis., states that the officers of that town have for several years past used shingle sawdust on the principal traveled roads in the town, where the land is very sandy. Sawdust is first spread on the road from 8 to 10 ins. deep, and this is covered with sand to protect the road against fire from pipes or cigars carelessly thrown or emptied on the roadbed. The sand also keeps the sawdust damp. The dust and sand soon become hard and packed, so that the wheels of the heaviest wagons make no impression upon the surface, and the roadbed appears to be almost as solid as a plank road, but is much easier for the teams. The road prepared in the above manner will remain good for four or five years, and will then require renewing in some parts.

The ordinary lumber sawdust would not be so good, of course, but if mixed with planer shavings might serve fairly well. Mr. C. M. Simons, of Friendship, Wis., states that on the sandy roads of Adams County, no sawdust is used, but clay and marsh muck are used instead; the clay making the best road when put on as it should be. Since the introduction of wide-tire wagons (4-in. tires) there has been little trouble with sandy roads, and very heavy loads are hauled over the sandiest roads without difficulty on 4-in.-tired wagons. Mr. Simons considers the use of wide tires on wagons and buggies of far more importance than any road filling that could be done in the county with the means at disposal for the work. In Juneau Co. some very fine roads have been made with sawdust. A road of this kind from Necedah to the Wisconsin River, a distance of about three miles, is a boulevard of the county, and it is a pleasure to ride over it. In that county sawdust is convenient and cheap. In Adams county, roads which have been well graded, and have trenches about 18 ins. wide and 10 ins. deep, filled with clay, and having about 2 ins. of sand on top, just where the wheels run, have made the best lasting roads for all kinds of use, and are the cheapest that can be made, though buckwheat, rye, and sorghum straw have been used with good results.

FINISHING RAILWAY CAR JOURNALS BY BURNISHING.

One of the best means of avoiding trouble from hot boxes is to give the journals and bearings as smooth a surface as possible, and we illustrate herewith a burnishing roller, designed by Mr. L. Bartlett, Master Mechanic of the Missouri Pacific Ry., at St. Louis, Mo., and used for burnishing the journals of car axles, and for crank pins. The roller is of tempered steel, about 3¾ ins. diameter, and the face, 5-16 in. wide, has a highly-polished surface. The burnishing is done after the journals have been finished in the lathe, the burnisher being held by a wrought-iron bar placed in the headstock of the lathe. This treatment gives a remarkably smooth and dense surface to the journal. The accompanying cut is reproduced from the "National Car and Locomotive Builder," to which paper we are also indebted for the description of the device.



Rollers for Burnishing the Bearings of Axles and Crank Pins.

DOUBLE LININGS OF CONCRETE AND PAVING STONE FOR RESERVOIRS.

A correspondent, under date of Jan. 29, questions the necessity of using stone paving on reservoir slopes in addition to a concrete lining, in the following language:

> In looking over the article on "The New Water Supply of Syracuse, N. Y." (Eng. News, Dec. 13, 1894), I notice a novel arrangement of the inside slopes. The lower portion of the slope (beneath the berme.—Ed.) is concreted, while the upper portion is both concreted and paved. I do not see the necessity of the paving, especially if the concrete is well made and good. The older practice is to bed the paving on a layer of broken stone, a much cheaper material than concrete. It seems to me where the latter is used paving would be superfluous.

I also notice from the Astoria, Ore., water-works specifications that the slopes are concreted, and in addition a course of brick is laid on top of the concrete. It also seems to me that the concrete would be sufficient.

A letter from this Journal, addressed to Mr. W. R. Hill, M. Am. Soc. C. E., Chief Engineer and Superintendent of the Syracuse Water-Works, has brought a reply, dated Feb. 5, containing the following reasons for using concrete at Syracuse:

> In regard to using both concrete and paving on our reservoir, I would say that after a long consideration I deemed that both were necessary. Concrete when exposed to the action of the frost will flake and chip off and if used on a reservoir of any considerable size would be liable to be greatly damaged by the jamming of ice. I am unable to learn of any large reservoir where only concrete has been used. On smaller reservoirs where there would be very little wave I might recommend the use of concrete without the stone paving.

We also addressed a communication on this subject to Adams & Gemmell, of Pendleton, Ore., the engineers for the improvements now under way at Astoria. Mr. A. L. Adams replied to our queries, under date of Feb. 8, as follows:

> Regarding the matter of reservoir linings in general, I should not feel justified in stating that a concrete lining is sufficient, and I should be equally averse to claiming that a paving on top of the concrete is always a justifiable additional expense. I do not wish at present to enter upon any extended discussion of a matter wherein engineers must be guided largely by local conditions, but in a general way will say that I have never succeeded myself nor seen any one else succeed in building a reservoir of concrete alone without the development of troublesome cracks, probably due to expansion and contraction, resulting from changes in temperature. It is the part of wisdom to provide against trouble resulting from the formation of these cracks by supplying some sort of an elastic surface, for which, an asphalt coating answers admirably. If, in addition to this tendency on the part of concrete to crack, there is any probability of some settlement taking place, the more care is necessary in the design. Under these conditions my idea is that the concrete layer may be somewhat lessened in thickness on the slopes, and a layer of brick laid either in cement mortar or in asphalt put on top of the concrete with excellent results, the finishing coat of asphalt being put on finally, as when the concrete alone is used.

The specifications for the Astoria reservoir call for 6 ins. of concrete on the bottom and inner slopes, the concrete on the slopes to be covered

with one layer of brick laid flatwise in mortar at right angles to the slope, both the brick and the concrete bottom to be finally covered with ¼-in. of cement mortar. Alternative bids were asked in the specifications for laying the brick in hot asphaltum.

Doubtless, other engineers have had experience with unprotected concrete on exposed reservoir slopes, and as the question under discussion is an important one, we invite statements of the results obtained under such conditions.

STORAGE BATTERIES IN AN ELECTRIC RAILWAY POWER STATION.*

The electric street-car railway from Zurich to Hirsladen differs from all other street railways from the fact that in the generating station itself secondary batteries are used to equalize the load upon the machines. It was at first intended to use machines only, but the responsible contractors for the work, who were the Maschinenfabrik Oerlikon, after being approached by the Hagen accumulator works, made satisfactory preliminary tests and eventually decided to use secondary batteries. The generating machine is shunt-wound, and the battery is in parallel with it across the mains. Thus a constant load is obtained upon the engine, which works at its highest efficiency. There are special automatic cell-regulator switches which are controlled by the potential, and the dynamo, therefore, charges a varying number of cells. The cells which lie between the charge and discharge points are charged by a small auxiliary shunt machine, and the field magnet coils of the latter being across the leads to this varying number of cells, automatic control of the dynamo is obtained. Automatic magnetic cut-outs are used in the circuits to prevent the current from the cells driving the dynamos as motors.

The conductor is carried on poles and is divided into four parts insulated from one another. The road is of meter gage and is 2.8 miles long, with only 233 yds. of level line. There are 3,300 yds. of gradient varying from 0.15 to 3%, 880 yds. varying from 3 to 5%, and 543 yds. varying from 5% and above. The steepest grade is 6.48%, which is in the Klosbachstrasse and is 87 yds. long, while it has a curve of 27.2 yds. radius at the end.

From the power station up to the Kreuzplatz, a distance of 4,950 yds., the sum total of all the rises gives 124 ft., which is an average rise of 0.837. In the contrary direction the total of all the rises is 210 ft., which gives an average rise of 1.41%; the average rise, therefore, in each direction is 1.127. Each carriage is built for 12 persons sitting, and 12 to 14 persons standing. The weights are as follows:

	lbs.
Car empty	5,060
Weight of electrical apparatus	3,200
Weight of passengers, driver, and conductor	3,960
Total	12,210

The greatest output of energy is required in the Klosbachstrasse, where, as stated, the gradient is 6.48%. With a coefficient of traction of 26.4 lbs. per ton, and a speed of 10.8 ft. per second, the work required is 18.8 HP. at the motor. In order to be able to start, 25 HP. must be available. If it be allowed that the average load of the car is only 1,320 lbs., which is a low estimate, then the average total weight moved is 9,570 lbs.

The single journey lasts 26 minutes, and with 2 minutes' stop at the end the double journey occupied 54 minutes. The author estimates that the average output of the motor is 4.72 HP., allowing for 25% excess at starting. The power station is at the end of the line, and provided with two Galloway boilers, built by Messrs. Escher Wyss & Co., of Zurich. Each boiler has a heating surface of 624 sq. ft. One boiler acts as a reserve. There are two large* steam boilers, each of 90 HP., but capable of developing 100 HP., and one small engine of 5 HP. Each of the two large engines drives by belting a shunt-wound dynamo, which develops from 450 to 550 volts and 100 amperes. Only one set is at work at one time, so that there is one always in reserve. The small engine drives direct a shunt-wound dynamo, developing 100 volts and 30 amperes, or 150 volts and 20 amperes; this is the auxiliary machine previously alluded to, and it has been found that it need only be worked once in two or three days for some hours. The station is so arranged that as much more power could be put in, giving three times the output, with a complete set in reserve.

The batteries are placed between the boiler-house and the engine-house, and consist of 300 cells, with a capacity of 245 ampere-hours; the charging current is 63 amperes and the normal discharge 81 amperes, but this rises to 162 amperes, and on emergency 243 amperes can be taken out. The charge is sufficient to carry on the whole work of the line for three hours.

The special automatic double-switch is designed for 150 amperes, and to control 28 groups of three cells each; it moves over two contacts per second, and, therefore, can switch in or out 84 cells in 14 seconds. There is a six-minute interval car service, and also a twelve-minute interval service; with the former nine cars are on the road together and with the latter five cars.

If the efficiency of the dynamo, allowing for loss in the belt, be taken at 90%, an average loss in the conductors of 5%, the efficiency of the motor and apparatus at 80%, and the loss in the accumulator at 5%, then the total combined efficiency will be 64.98%. Taking the average output per car at 4.72 HP., then the steam-engine must develop about 65 HP. for the 6-minute service, and about 36 HP. for the 12-minute service. The current at 520 volts will be 83 amperes for the 6-minute service, and the result is that about 80 amperes are constantly given out by the dynamo, while there is a varying effect on the battery from 30 amperes charge to 30 amperes discharge, the line current required varying between 50 and 110 amperes.

From 6.16 a. m. to 7.04 a. m. there is a 12-minute service, from 7.04 a. m. to 7.58 p. m. a 6-minute service and from 7:58 p. m to 9:04 p .m. a 12-minute service. This gives a six-minute service for 12 h. 54 m., and a 12-minute service for 1 h. 54 m. The total daily output is therefore 907 brake HP. hours, and as 2,960 lbs. of coal are consumed, there is a consumption of 3.3 lbs. of coal per brake HP. hour. In power stations, where no accumulators are used for street-car service, the author states that 7.5 lbs. of coal and upwards per brake HP. hour are used, so that there is a daily saving of 2,000 lbs of coal; and, with coal at 31s. per ton, this is a yearly saving of £516 due to the use of the battery.

The battery and switch apparatus complete, erected in working order, cost £1,480, so that yearly one-third of this is saved in coal; allowing 5% for sinking fund, and 5% for repairs, the battery would be paid for out of coal savings in four years. One of the chief advantages, however, is that it is unnecessary to keep the second boiler under steam. The author also points out that the coal consumption will hereafter be diminished, as the engines are at present working non-condensing, but when the work is finished completely they will work condensing, and he thinks it clearly proved that the use of the accumulators is a great advantage for street-car service.

*From Elektrotechnische Zeitschrift, 1894, p. 356; in "Abstracts of Papers," Institution of Civil Engineers.

* European ideas of a "large" steam engine sound curiously in this country.—Ed. Eng. News.

ELECTRIC LIGHT FOR THE FIRE ISLAND LIGHTHOUSE.

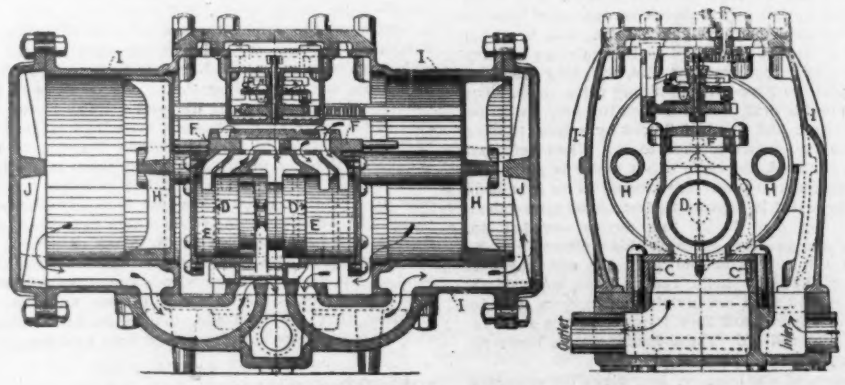
The use of electricity for lighthouses and lightships has been under consideration for some time by the U. S. Lighthouse Board, and it has already been applied to a lightship; but its first application to land service will be at the Fire Island lighthouse, on the south shore of Long Island, where the plant is now being installed. There will be two Serrin lamps, which are the pattern used for this class of service in France, and the carbons will be 0.88-in. diameter (23 mm.), with 0.175-in. length of arc and a difference of potential of 48 volts. The intensity of the light in the plane of the lens is estimated at 25,000,000 c. p., and the maximum light given by the lamp with the lenses removed is set at 8,000 c. p. The plane of the lens is 168 ft. above the water level and the light will be visible for 25 miles. It is estimated that but for the convexity of the earth the light would be visible for 142 miles. The two lamps are carried on a turntable worked by a crank from the outside of the lens, and the table can be moved laterally from the lens for the purpose of cleaning and adjusting the lamps. To insure that the arc is kept steadily in the exact focus of the lens, a small double-convex lens is placed at the side of the large lens and so arranged as to throw a beam of light on a standard at the side of the lighthouse, and when this beam is above or below a horizontal line on the standard it indicates that the position of the arc must be adjusted. The current is led to the lamp through the revolving platform which carries the lenses, the contact connection between the fixed and moving parts being effected by a steel pin travelling in a small circular trough of mercury. The other end of the circuit is completed by a ground. The switchboard for the lamp is in the lighthouse, and has an ammeter, voltmeter and four switches, each carrying 25 amperes. The power plant and fittings will be in duplicate throughout, to avert the possibility of breakdowns. The power plant will be contained in an iron building, 24 × 52 ft., and will comprise two Ideal engines of 25 HP., with friction gearing for direct driving, two General Electric Co. alternators of 7½ KW. each, which develop a current of 520 to 550 volts when runaing at 800 revolutions per minute. A separate exciter of 1½ KW. is supplied for each alternator. Steam is supplied by two 25-HP. Fitzgibbon boilers, furnished by W. R. Fleming & Co., of New York, and draft is supplied by a 40-ft. smokestack. Each part of the duplicate switchboard will have a rheostat and a switch for the exciter, a rheostat for the arc current, an ammeter, voltmeter, station transformer, pole changer, ground detector and two lightning arresters. The powerhouse will be 200 ft. distant from the light house, and the wiring will be placed underground.

The revolving lens was made by Lepaute, of Paris, and was exhibited at the Columbian Exposition in 1893. It is of the ordinary form of construction, but of exceptional size, being 9 ft. in diameter, with a weight of over a ton, and was originally intended for use with oil lamps. The frame of the lens floats in a trough filled with mercury, and is revolved by gearing operated by a heavy weight and regulated by a governor whose balls revolve in a basin with which they come in contact when running too fast, the friction then regulating the speed. The lens is revolved to give a flash every five seconds.

During the change from the present oil lamps to the electric system, a temporary electric light will be fitted in a lantern built on a bracket frame projecting beyond the top platform of the lighthouse.

THE METROPOLITAN WATER METER.

The possibility of curtailing waste and of collecting revenue for all water used or wasted, through the aid of meters, is now almost universally admitted by water-works officials. As to the type of meter most available for use, from the standpoints of reliability, life and cost of installation and maintenance, there is naturally much difference of opinion.



THE METROPOLITAN WATER METER.

Of the various meters of the positive type, but little has ever been said in the technical journals in regard to the Metropolitan. This meter has been quite extensively used in Boston, the last report of the Boston Water Board stating that, of 4,507 meters in use on Jan. 31, 1894, 485 were

made by the Metropolitan Meter Co., of Boston. This meter, according to information furnished us by the company, is of the reciprocating type, with a main or measuring piston, and an auxiliary valve or flow reversing piston. Its makers claim, as a special point in favor of its durability and permanent accuracy, that it has no rubber or leather parts, it being made of composition or cast iron with gun metal working parts. Both of the valves are flat-balanced, sliding under a cover designed to relieve them from pressure and the consequent friction and wear. The pistons are rotating and the registering device consists of a positive rack and pinion movement, the rack being fitted between the two heads of the piston and traveling simultaneously with it.

Thus a record is made of the total distance travelled by the piston and variation in the length of stroke does not affect the accuracy of the meter, as it does with meters which are arranged to merely count the number of strokes made.

The accompanying sections give a general idea of the design of the meter. The water enters the chamber between the two piston heads, H, H, then passes through the valve ports to the cylinder end, J, and against one of the piston heads. This piston head responds to the pressure, and encounters the auxiliary flat slide valve, F, which is carried along until passages are opened for water to enter the auxiliary cylinder, E. This operates the auxiliary piston, D, which moves main flat slide valve, C, and reverses the flow of water to the measuring cylinder, I, forcing the previously measured water to the consumer.

The makers of this meter also claim that it is of especial merit in case solid matter enters the meter, as it has power enough to shear off the obstruction and continue its operation.

Since writing the above the manufacturers have informed us that over 800 of these meters are now in use in Boston.

PAINTING, PAINTS AND VARNISHES AS APPLIED TO RAILWAY EQUIPMENT.

At the February meeting of the New England Railroad Club, of Boston, the subject for discussion was "Painting, Paints and Varnishes as Applied to Railway Equipment," which was opened by a paper on "Lucol," by Mr. James L. de Fremery, President and General Manager of the American Lucol Co., of New York. This material is a manufactured oil, made by refining the olein extracted from animal fat and oils, and then treating this product by a secret process, which converts it into a clear, transparent, yellow oil. A comparison of lucol with linseed oil was given on p. 138 of our issue of Feb. 28, and Mr. Fremery gave instances showing the superiority of the former. The gable end of the Imperial Hotel, New York, with an area of 55,000 sq. ft. of surface, was given two coats of lucol oil of old-ivory tint, requiring 1,692 lbs., or 0.27 lb. per sq. yd. for two coats, while painters estimating such work on a linseed oil basis figure on ½ lb. of paint per sq. yd. of surface, two coats, thus showing a saving of 46% in favor of lucol. Lucol was also used for the Starin pier shed at the foot of Cortlandt St., New York. This structure projects about 800 ft. into the Hudson River, and about eight months ago the bright new galvanized iron covering was given two coats of lucol paint, 6,047 lbs. of paint being required for 171,000 sq. ft. of surface. This paint was composed of 318 gallons of lucol, 3,272 lbs. of Atlantic lead and 392 lbs. of color. On this pier, as well as on the Lehigh Valley R. R. sheds, the paint is said to have been little affected after an exposure of about eight months, the paint being elastic and retaining its appearance better than linseed-oil paint would have done. As to longer exposure, instances were cited of painting done two years ago on the Brooklyn Bridge, and on the property of the Staten Island Rapid Transit Co., the Boston & Albany R. R., Boston & Maine R. R., etc. For a given quantity of pigment more lucol should be used than linseed oil, and the lucol paint should be flowed on with a full brush and rubbed out gently, except when a special surface is required, and the paint will run less than linseed-oil paint. Thus, for house work, 7 lbs. of green pigment to a gallon of lucol oil will equal 12 lbs. to a gallon of linseed oil.

Mr. Albert P. Dane, Master Locomotive Painter of the Boston & Maine R. R., sent a letter complaining of the absence of skilled labor in the paint shop. In one shop, where ten or twelve men are employed, only one beside the foreman was a skilled workman, the others being men and boys, first hired as cleaners, but who are set to work as painters when there is a rush of work. Then again much good work is spoiled by not allowing sufficient time for the drying of the different coats and of the varnish, this being especially the case with locomotives and tenders, which the transportation department insists on having out of the shops by a certain day. Instead of using oil for cleaning tenders, he considered that the paint and varnish would last longer if cleaned after each run with plenty of clean water and a little soap, applied with a soft sheep's-wool sponge, then thoroughly rinsed with water from a hose or sprinkler, and wiped dry with chamois skin.

Mr. G. W. Lord, Master Painter of the Fitchburg R. R., who also sent a letter, referred to the severe atmospheric conditions to which car varnishes are subjected, as for instance, when on a very hot summer day the cars (with sides so hot as to hurt the hand) suddenly enter the Hoosac tunnel, and come out into the hot sun with the sides wet and cold, covered with dust and soot. Cars should not be washed down with hot water, as this spoils the luster of the varnish. Mr. Alvin Phillips, manager for L. J. McCloskey & Co., varnish manufacturers, of Boston, Mass., said that a body varnish for the outside of car bodies must be not only capable of withstanding severe atmospheric conditions, but also the softening and corrosive action of steam, smoke, and gases from the engine, and the cutting action of dust and cinders. Mr. Charles E. Copp, Master Painter of the Boston & Maine R. R., pointed out that while good material is necessary, the proper use and proper care of the material are equally important. He considered that the men in charge of the painting and varnishing should have something to say as to when the cars need revarnishing or repainting. In testing varnishes by applying two or more kinds to the side of a car, one man should do all the work, as some men use more varnish than others, so that the varnish applied by a man using it liberally would show a better result than an equally good varnish applied less liberally. Wiping is better than washing for cleaning cars, as less water gets into the joints. Several speakers referred to the fact that a good deal of the trouble from dulling and cracking of the varnish is due to the work being turned out of the shops too soon. Mr. Bailey, of the Concord & Montreal R. R., advocated the use of shellac, using corn-starch as a filler, then four coats of shellac, and rubbing down with oil and fine pumice stone. Panels on which rubbing is done retain their gloss much longer. Mr. G. W. Rhodes, of the Chicago, Burlington & Quincy R. R., said that in the West less attention was paid to painting for the sake of appearance, owing to financial conditions, and on the locomotives of his road painting is only done to prevent rusting. In the same way the high finish of cars is temporarily abandoned, thus saving in labor expense.

The East River tunnel project is being revived by the New York & Brooklyn Tunnel Co., incorporated at Albany on March 6. The incorporators and directors of the company are: Thomas A. Patteson, Jr., Charles J. Schlagel, W. G. Amis, John C. Brucken, Charles Kushnmundt, John V. Bouvier, Jr., F. P. Delafield, Frank H. Knight, and Samuel Slater, all of New York. The declared purpose of the company is to tunnel the East River for a passenger and freight railway, with a New York terminus somewhere "between Whitehall and East 17th St.," and a Brooklyn terminus "between Atlantic Ave. and North 8th St."

A bill is before the Minnesota legislature proposing to raise money for the building of highways by taxing untaxed railway lands in the state 5 cts. per acre annually. This money is to be divided among the 43 counties containing railway lands, or two-thirds of the state, and it is to be expended solely for the improvement of roads. Mr. Goodell, President of the Good Roads Association of the state, prepared the bill and argues that it would build 2,000 miles of good roads annually, would increase the population 100,000 in the next ten years, and increase the taxable value of property in these counties $1 per acre in the same time, a sum aggregating nearly $37,000,000.

A course of six lectures on "How Electricity is Now Being Utilized" is to be given at Columbia College, New York city, by Mr. Francis B. Crocker, M. Inst. Elec. E., Professor of Electrical Engineering. The lecture will be given at 8:15 o'clock on Thursday evenings, commencing March 21, and the subjects are to be as follows: "How Electricity is Generated and Stored," "Alternating Currents," "How Electricity is Used for Heating and Lighting," "The Electric Motor and Its Use in Transmission of Power," "Electric Railways" and "The Telegraph and Telephone." The price of tickets for the course is $5, and tickets may be obtained from the secretary of the president of the college.

Electricity has been rated as a dutiable article by the Canadian Comptroller of Customs. The question arose in connection with importing it into Canada for power and lighting purposes from the plant of the Niagara Falls Hydraulic Power & Manufacturing Co. The Comptroller decides that it comes under the head of unenumerated articles and must pay 20% duty.

An auto-manual, or manual-controlled, block signal system is to be used on the Glasgow underground railway. The starting signal at each block is normally locked at "track blocked." In operating, say from C to E, the signalman at C will give the "be ready" signal on the bell, and the signalman at D will then (if the track is clear) lower the miniature signal arm in the C tower by pressing his electric plunger, which will also release an electric coil on the starting signal at C, for section C-D. The signalman at C may then lower his starting signal (which hitherto was electrically locked) and allow the train to proceed, notifying the man at D that the train has left, and the latter will press a second plunger which will raise the miniature signal arm in the C tower to "track blocked," and at the same time effectually lock the starting signal there until it is again released from the D tower. The signalman at D repeats the bell signals to E, and when the train has passed from C-D to D-E he signals back to send on the second train from C. But as long as the first train is in block section C-D it is impossible for the signalman at D to signal "line clear" back to the signalman at C, for his plunger is electrically locked until the train passes into D-E. Outside each starting signal will be a treadle operated by the engine, and when that at D is depressed it electrically releases the plunger in the tower, so that the signalman can then release the lock of the starting signal at C and signal the man at that tower to send on the next train. This mechanism makes it impossible to give a "track clear" signal by mistake.

An ingenious apparatus for checking the time of entry of workmen at factories in a way that admits of no dispute, says "The Engineer," has been made by Messrs. Pascall and Stocker, of Waterloo road, London, S. E. A clock is fitted with a tube holding a column of numbered tickets or blanks, which are released one by one at every five minutes or other suitable interval, and are received in a shoot or tube. The workers drop their tickets into the same tube as they enter the factory. The mixed tickets are taken out in a column or pile, and, being sorted, the tickets dropped by the clock indicate the time at which the workmen's tickets were placed in the apparatus, as the latter are between the clock tickets.

A decision in the air-brake patent litigation between the Westinghouse Air-Brake Co. and the Boyden Power Brake Co., of Baltimore, was rendered by Judge Morris in the U. S. Circuit Court at Baltimore on March 11. The Boyden Co. was sued for infringement of claims 1, 2, and 4 of Patent No. 360,070, issued to Geo. Westinghouse, Jr. The decision of the court holds that the Boyden triple-valve on which suit was brought, infringes Claim 2 of the patent, but does not infringe Claims 1 and 4. In the patent in suit, Claims 1 and 4 include the use of a supplementary emergency valve separate from the valve, and the court decided that in the Boyden triple-valve the emergency valve forms part of the main valve, and is not independent thereof. Claim 2, which is declared to be infringed, is as follows:

In a brake mechanism, the combination of a main-air pipe, an auxiliary reservoir, a brake-cylinder and a triple valve having a piston whose preliminary traverse admits air from the auxiliary reservoir to the brake-cylinder, and which by a further traverse admits air directly from the main-air pipe to the brake-cylinder, substantially as set forth.

This claim is said to cover every triple-valve which has been thus far manufactured by the Boyden Co. The decision is accompanied by the usual order for an injunction against and an accounting by the defendants in the case.

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We omit in this issue our regular inset sheet of drawings, and in its stead add eight extra pages to this number in order to present to our readers in full in one issue the report of Capt. W. H. Bixby, U. S. Engineers, upon wind pressure in engineering construction. We risk nothing in saying that this monograph is the most complete and reliable treatise upon this subject that has ever been written. It covers practically all that has ever been recorded upon this important element in structural design, and gathers under one head much matter now so scattered as to be practically unavailable to the profession at large. The report has been printed by the government, but the edition was limited to about 500 copies, we understand, and under the present method of disposing of public documents of this character, the engineers, who really would derive profit and pleasure from studying this report, stand a very small chance of obtaining copies. The report is too generally useful to the profession to be buried in this manner, and we therefore reprint it in full, being enabled to do so by the permission of the Secretary of War.

For the convenience of any readers who may wish to bind or preserve this report separately from the files of the paper, we have placed it upon the last ten pages of the issue, so that it may be removed intact without mutilation of the rest of the paper. We may say further that Capt. Bixby is still continuing his researches on this subject and would be pleased to receive from any one interested in it copies of any printed matter not referred to in his monograph, or any information.

In view of the present generally admitted importance of fully and intelligently studying the effect of wind pressure, and applying the results of such study in the design of large structures, it is astonishing how little attention was given by engineers to this possible effect only a few years ago. The Tay Bridge disaster of 1880 seems to mark the point of departure. Previous to that disastrous event the literature upon this subject was very scanty, and the experiments previously recorded were of very uncertain value. Up to 1880 American and English bridge engineers who considered the question at all attempted to provide against a possible wind pressure of from 30 to 50 lbs. per sq. ft. But the rules of design in this respect were empirical and lax in application, and in many American bridges the actual cross sections of the wind-bracing show that if these pressures were suddenly applied to one girder alone the resulting stress would be very high, and in some cases would closely approach, if not exceed, the elastic limit of the metal. Many English bridges were built without wind-bracing at all, or with bracing totally inefficient against the pressures named above.

How little was really known by engineers of the true effect of wind pressure and of the means of providing for it in structures, is shown in the published controversy following the overturning of the Tay Bridge. There was a wide divergence of opinion as to the amount of such pressure, the allowance to be made for it, and especially in the methods of calculating the area of surface supposed to be exposed to the effect of wind pressure. As an example of the latter point of difference in opinions, it may be said that English engineers assumed an exposed area of 800 sq. ft. in the Tay Bridge, while Mr. C. Shaler Smith, by the rules of American practice, measured this surface as 2,576 sq. ft., a difference of 3.2 to 1. The controversy of 1880-1881 brought out many valuable papers and personal observations upon the force and action of wind and tornadoes upon bridges and other structures, and these have been followed since by many careful experiments with more delicate and modern instruments, and a general remodeling of practice in considering this element of stress and possible danger.

The history of this progress is detailed to date by Capt. Bixby, and the general conclusion seems to be that while we know much more than we did in 1880, we have yet much to learn regarding the power and vagaries of wind storms as exerted upon the works of engineers. Our ordinary recording instruments are found to be too imperfect to permit the founding of general laws upon the results recorded by them; and this is especially true in the case of long span bridges, towards the building of which there is now a decided tendency among engineers and capitalists. Engineers, with all the light of later experiment, still vary in their practice, and in the design of long-span bridges Capt. Bixby finds a difference of 100 per cent. between several modern methods of estimating the actual wind stress upon such structures. The cash value of reducing this margin in what is now recognized as one of the costly features of the bridge, and the importance of reducing the chances of danger to the public that may follow the work of a generally competent but too economical engineer are self-evident points. Engineers owe it to themselves and to the public they serve to make every effort to reduce to the lowest limits all factors of chance or ignorance; and this can only be done by further intelligent and more careful study and experiment. Isaac Newton, 200 years ago, laid down the general law of the relation between wind velocity and wind pressure, and his law remains undisputed to-day. What we want now are the actual pressures upon existing structures of large areas; and until we know more about this feature than we do at present, the 20-storied buildings going up about us must take their chances in exceptional storms, or depend for their stability upon an unknown and costly excess of section in their members.

In connection with this report we would call the attention of readers to the interesting recent experiments on wind pressure contained in our issue of Feb. 14. In this article a Danish engineer considers the effect of suction produced by a current of air striking a plane surface at various angles, and his results are remarkable in showing how large a percentage of the total effect is covered by this suction. While these experiments apply more to buildings than to bridge construction, this suction effect may well explain some hitherto puzzling bridge disasters, like the vertical lifting of the Louisville & Jeffersonville bridge. The point is made by the writer of the article, that while a bridge may be carefully designed to resist a horizontal wind pressure, the wind may strike the structure on the under side at an angle of 10° with the horizon; and in such an event the author figures that the upward suction, or lifting effect, may equal 45% of the normal pressure. The important lesson taught is that the wind very often really acts in a direction quite different from that assumed and provided for, and dead weight and secure anchorage to piers become very important factors in security against the erratic action of wind storms.

The New York Rapid Transit Commission has followed up its adoption of a route, as noted in our issue of Feb. 21, by the adoption of a general plan of construction which seems to be on the whole a very satisfactory solution of the difficult problems presented. Two tracks on a level are to be provided for, from Battery Place to Vesey St., with provision made for two more tracks between them when the traffic demands it; and from Vesey St. up Broadway to 14th St. there are to be four tracks, as nearly as possible on a level. From 14th St., on the west side, there are to be four tracks on a level to 135th St., and two tracks from that point to 185th St., so placed on the sides of the street that two more may be built between them when the growth of traffic makes it necessary. On the east side of the city there would be four parallel tracks on a level from 14th St. to 44th St., and two parallel tracks from 44th to 146th St.

This plan of construction, with the 13½ ft. of width per track which the Commission has decided to be necessary for safe operation, will make necessary the taking of the vault space along Broadway, which will necessitate an increased outlay of some $5,000,000. On the other hand, it provides for an improvement which has been advocated in this journal from the first, viz., the provision of pipe galleries at the sides of or beneath the railway tunnel, in which all sewers, water and gas pipes, wires, and other sub-surface structures under Broadway will be placed. This disposition of these street obstructions, while costly in the beginning, has many advantages and future economies. In the first place, it permits the building of the subway in open cut, with its roof as near the street surface as possible; reduces the depth of excavation, and consequently the danger to buildings, to a minimum, and eliminates the very doubtful engineering problem of tunnelling under these obstructions and of attempting to maintain them intact during construction. Broadway is particularly obstructed with pipes, drains and conduits of all kinds; the underlying soil is sand or gravel, and any attempt to tunnel under obstructions of this kind is practically without precedent, and would be attended by risk and dangers that would greatly swell the estimate and proposal of any experienced and responsible contractor. As a consequence, the removal of a potent element of doubt, risk, and outlay, by this simplification of construction, should largely offset the cost of acquiring the vault space along Broadway needed for the four tracks on a level.

Aside from the immediate advantages of an open cut of minimum depth for the building of the subway, the definite disposal of these sewers, pipes, and wire conduits in accessible galleries has other and far-reaching advantages. Such disposal practically settles for all time the vexed question of street openings for repairs, additions, and changes in these sub-surface structures, and permits, what is now impossible, the maintenance of a good street pavement at a reasonable outlay. Were it possible to compute the money expended, even during the last ten years, in digging up Broadway and again laying down the pavement with all its attendant evils of obstruction to traffic, uneven settlement, and consequent bad surface, it would probably be found that the aggregate amount far exceeded the cost of roomy and substantial pipe subways the whole length of the street.

Moreover, in this age of discovery and introduction of new appliances for the convenience of man, there is no assurance but that all Broadway may be dug up again within the next ten years for the replacement of some of the material now buried beneath it, and there is every probability that this will happen. In providing against this contingency, therefore, the action of the Rapid Transit Commission must be commended, and few will doubt but that the larger expenditure required in providing for a tunnel and subway space 62½ ft. wide along Broadway will prove to be money wisely invested.

The Iron & Steel Institute of Great Britain is distinguished among the world's engineering

societies by the fact that it ignores national boundaries and racial prejudices to a greater extent than any other engineering society in the world, with the exception of those that are actually international organizations. The Institute's cosmopolitan character is shown not so much by its membership, although this includes a large number of the prominent metallurgical engineers in other countries than Great Britain, as in the meetings which it has held in foreign countries and the extent to which its transactions are contributed to by foreigners and illustrate and describe foreign practice. The Institute's freedom from insular prejudice is also well shown by its frequent bestowal upon foreigners of the Bessemer medal, established by Sir Henry Bessemer, and annually awarded to some engineer deserving distinction for his work in the advancement of iron and steel metallurgy. The bestowal of this medal upon John Fritz, of the Bethlehem Iron Works, a year ago, is familiar to our readers. The announcement has just been made that this year also this honor has been given to an American engineer, the recipient being Mr. Henry Marion Howe, Past President of the American Institute of Mining Engineers. Mr. Howe's great work on the "Metallurgy of Steel" alone makes this distinction well deserved. A portrait and biography of Mr. Howe were given in our issue of July 6, 1893, at the time of his election to the Presidency of the Mining Engineers. This is the third time in five years that the Bessemer medal has been awarded to an American, Mr. Abram S. Hewitt having received it in 1890, the year when the Institute held its session in this country.

In presenting the Darien ship-canal project of Mr. Karwiese in this issue, little more is intended than to put upon record one more scheme for cutting the American isthmus. In the voluminous correspondence which we have examined, the projector gives evidence of having conscientiously studied this country and of having made such instrumental surveys as his means permitted; and if tunnel routes for a ship canal are to be considered at all, he seemingly has discovered the line with the shortest tunnel. But, in comparing it with other canals, he persistently refers to his route as having upon it only "28⅝ miles of canal." This is true, so far as a wholly artificial canal excavated in the native rock is concerned; but, by his own showing, and including the rivers on both sides, which he proposes to dredge out and to rectify, the distance from the Gulf of Darien to the Pacific Ocean is about 94 miles, or nearly twice the length of the proposed Panama Canal, and three times longer than the more northerly, and thus better, San Blas route.

For navigation purposes, it matters little whether the ship is passing through an artificial canal or a crooked river channel; the expense and danger are about the same, and hence the length of his line offsets, to a great degree, the alleged greater economy in construction.

As to the prevalent objections to tunnels on ship-canal routes, their advocates claim, with some justice, that it is yet a question which would suffer the most by an earthquake convulsion, a well-designed tunnel in solid rock or the concrete or masonry construction in large canal locks. If the earthquake were severe enough there is little doubt but that it would destroy any work that man could build in this region. But we believe the real objection lies in the very uncertain character of the rock in the mountains to be pierced, and in the fact that deep borings, as a rule, serve to mislead rather than to guide, in estimating the character of this rock beforehand. This was the case at Panama, and the rock there was found to be very much broken and varied in character, and utterly unfit for tunnelling purposes. In the case of the San Blas route, with its seven-mile tunnel, Mr. Kelley's engineer believed that he would find granite and trap in his tunnel; but he also provided against the contingency of bad rock by adding over $32,000,000 to his estimates for tunneling. With the arch span demanded for the passage of modern steamships this lining is absolutely necessary if there is the least suspicion of loose or uncertain rock over head, and any safe estimate for a tunnel of the required dimensions would have to include this contingency. As seen in the figures given for the San Blas route, this lining item adds nearly $5,000,000 per mile to the tunnel cost; and as Mr. Karwiese seemingly does not include this in his estimate, his figures of total cost should be increased by about $11,000,000, making his total estimate $59,000,000.

A correspondent, Mr. W. L. Hedenberg, C. E., suggests that an annual tax of $1 be levied on all the horses in New York city, and the proceeds be put at the disposal of the street cleaning department. He estimates that there are about 200,000 horses in this city, and that a sum of at least $140,000, clear of the cost of collection, could be obtained from this source. The chief argument in favor of such a plan is the fact that horses are chargeable with very much of the daily littering of our streets, and the tax suggested is not an onerous one to the owners under these circumstances. While the total amount thus raised would be but a small percentage of the annual expenditure in street cleaning in New York, it is an amount worth considering in this connection.

THE CANDLE-POWER OF ARC LAMPS.

A great deal of friction between electric lighting companies and the municipal authorities in charge of street lighting has been caused by disputes over the candle-power of arc lamps. From the beginning of the electric lighting industry down to the present time, arc lamps have been rated by their "nominal" candle-power, and this "nominal" candle-power has been almost invariably a much greater than the actual candle-power given in service. Photometry, however, is a little known art, and was much less known when the arc lamp was first put on the market than at the present day. The brilliancy of the electric arc was so much beyond that of any previous source of artificial light that the general public, and even those in charge of local electric lighting plants, accepted these ratings in good faith, and contracts for street lighting were made based on these ratings, both parties supposing that a 1,000 c. p. lamp gave 1,000 candle-power as regularly as the dynamo spun around at the station.

It was not long, however, before complaints began to be rife concerning the amount of light given by the lamps both indoors and outdoors. These were due in the first place not alone to a lack of actual knowledge as to what the lamps really were doing, but also to a highly exaggerated notion of the area which a lamp of 1,000 or 2,000 candle-power really should illuminate satisfactorily. That the intensity of light varies as the square of the distance from its source is a physical fact which every intelligent man is supposed to know; but it is one thing to know an abstract fact and quite another thing to so appreciate its importance as to make practical use of it in daily life.

The complaints of the storekeepers who had expected a single arc lamp rated at 1,000 c. p. to give several times the illumination of a dozen or twenty gas lamps, and of the street lighting committees who had located arc lamps too far apart, finally resulted in some actual photometric tests, the result of which was about equally surprising to the electric lighting men and the purchasers of light. In the first place, it was found that the actual candle-power of an arc lamp was far less than its rated candle-power. In the second place it was found that the measurement of arc lamp candle-power was difficult to accomplish with any approach to accuracy, and this was especially the case if the candle-power was required to be measured with the lamp in position in the street. In the third place, the fact was developed that light radiated from an arc lamp is very unequally distributed. According to diagrams published in our issue of Dec. 19, 1891, if the candle-power given off in a horizontal plane by an arc be taken as 200 c. p., then that directed downward in a line making an angle of 20° with the horizontal may be 400 to 700 c. p., and the maximum of 650 to 1,050 c. p. is attained at an inclination of between 35° and 50°. At 60° the light falls off to some 300 to 700 c. p. This is the actual light emitted by a lamp consuming about 405 watts of electrical energy per hour, or about the size of lamp that has been ordinarily rated at 2,000 c. p.

Under all these circumstances, the absurdity of contracting to furnish street lights of a certain candle-power, without specifying when and how the candle-power to be measured, is manifest. At the convention of the National Electric Lighting Association in 1894 a committee recommended that instead of rating arc lamps by candle-power they should be rated by the electrical energy consumed, and that a 2,000 c. p. lamp should be one absorbing 450 watts per hour.

But at the convention of the Association just held at Cleveland, Mr. L. B. Marks read a paper on "Arc Carbons and the Rating of Arc Lamps," in which he showed conclusively that the amount of light given out by the same lamp, taking the same amount of electric energy, varies as much as 25 to 40% according to the quality of the carbons used. The same law seems to hold good here as in the incandescent lamp, that is, the carbons which give least light per unit of energy expended last longest, and those which give the highest efficiency, that is, the greatest amount of light in proportion to the electric energy expended, burn away most rapidly. When we consider the fact that an arc lamp carbon becomes luminous by the vaporization of the carbon under the intense heat, the reason is apparent why the soft carbons, which burn away most rapidly, give the best light.

Besides the mechanical density, the composition and form of the carbon have much to do with the efficiency of the lamp. It has been very generally supposed, both by electric lighting managers and carbon manufacturers, that an absolutely pure petroleum coke carbon would give better results than any other. Tests by Prof. Marks, however, showed that carbons made with special reference to secure absolute purity gave less satisfactory results than ordinary commercial carbons. These very pure carbons began to hiss at a potential of 53 volts, corresponding to a consumption of energy of 503 watts, whereas ordinary commercial carbons did not hiss till the potential fell to 41 to 51 volts, corresponding to 390 to 485 watts.

Again, cored carbons have come largely into use, especially for indoor service, as they do not hiss until the potential falls to some 31 to 35 volts. Tests show, however, that such carbons, while giving a very steady light, give less light by 15 to 20% for a given consumption of energy than a solid carbon. With alternating current arcs this rule is reversed, and the solid carbon gives less light with the same consumption of energy than the cored carbon. It is also found that on the whole the direct current arc lamp gives more light per unit of energy expanded than the alternating lamp.

A German scientist has propounded the law that with a given current the candle-power of an arc varies inversely with the square of the diameter of the carbon. In other words, the emission of light increases rapidly with increase in the amount of electricity forced through a unit area of cross-section of the carbon. Of course, this law is true only in a roughly approximate way.

Prof. Marks also stated in the paper above referred to that the candle-power of a lamp is influenced materially by variations in the character and size of grain of the pulverized crude material, in the nature of the binders, the consistency of the mixture when finished, in the pressure at which the carbon is molded or squirted, in the duration of carbonization and the temperature at which it is performed. Finally, the quality of the light varies materially with the current used. Arc lamps on incandescent, or constant potential, circuits produce more yellow rays, whereas with the ordinary constant current arc lamp the rays at the other end of the spectrum predominate, giving the light its distinctively violet tinge.

In view of all these facts, the question arises, on what basis should a contract for street lighting by arc lamps be made? The old basis of contracting for so many street lamps of so many nominal candle-power each is absolutely meaningless. On the other hand, if a city contracts for street lamps each consuming 450 watts of energy it may get good light or poor light, according to the kind of carbons used. In fact, there will be a certain tendency for the electric lighting company to try to increase its profits by using hard carbons of low efficiency, which will burn away slowly, rather than soft, rapid-burning carbons of high efficiency. It may be said that the electric lighting company will en-

deavor to give the most light possible from the given current consumption in order to give satisfactory service; and this may be true where street lighting contracts run for only one year. But it is generally admitted that these short-term contracts for public lighting are poor policy for the public, as well as for the contractor. Low prices for street lighting combined with efficient service can never be expected if the contractor has no security that the plant he installs will be in use longer than a twelvemonth. What is wanted is some definite basis of agreement under which a city can contract for lighting for a five-year or ten-year term, with full assurance that it can at any time determine whether it is receiving all it has agreed to pay for.

In the light of present knowledge it would seem that no contract which merely specifies the number of watts a lamp shall consume, nor states it to be of so many nominal candle-power, is likely to give satisfaction. If the lamp is to be rated by watts, then some provision should be inserted in the contract requiring the electric lighting company to furnish carbons which will convert the energy into light with reasonably high efficiency.

But there are many indications that no rating of street lamps on any other basis than candle-power is likely to come into general use. What is actually purchased is light, not electric current. The lighting company provides and maintains the apparatus for converting the current into light, and is entitled to credit for doing this with efficiency. If a town or city were to establish its own lamp-posts and lamps, and furnish its own carbons, it would then be entirely proper to purchase current supply of a given amount at a given rate per lamp. This practice, however, has never been adopted, save possibly in isolated cases.

A still more potent reason why the candle-power rating is likely to be adhered to is that it is a basis which the non-technical man can understand. The city authorities who contract for street lighting will require the contract to be put in terms within their comprehension.

The proposition has been made in this connection that instead of measuring the intensity of the sources of light, contracts might be made to specify the amount of illumination. A valuable paper, read before the Institution of Civil Engineers and given in our issue of Nov. 24, 1892,described the measurement of illumination and a convenient portable photometer for effecting such measurements. This subject has been recently brought up again by a paper read at the Cleveland meeting of the Electric Light Association by Messrs. Houston and Kennelly, in which the authors advocated the measurement of illumination and described an instrument which they had invented for that purpose. In this paper the plan was advocated of basing contracts for street lighting upon the illumination furnished rather than the intensity of the sources of light. It seems very doubtful, however, whether such a basis for lighting contracts is likely to find favor. The illumination along a city street, for example, is greatly influenced by the character of the buildings along it, and the relative reflection and absorption of light from their walls. Unless a lighting company had entire control over the spacing and location of the lamps it could hardly venture to enter into such a contract.

On the whole, therefore, the reform that seems most desirable, with our present knowledge, is a reform in the rating of lamp candle-power. A contract for street lighting should specify that each arc lamp shall consume so many watts, and shall have an intensity of at least so many actual candle-power in a direction making an angle of say 35° with the horizon. This candle-power should be that which the lamp is capable of actually showing under test when supplied with carbons of reasonably high efficiency, and not the meaningless candle-power rating of the manufacturers.

The parties to such a contract should fully understand that the candle-power of an arc lamp is subject to more or less variation, and that it cannot be measured with the exactness that weight or length can be determined. On the other hand, it can be measured with accuracy sufficient to determine whether the city is getting what it pays for in illumination, and to check any effort of the contractor to economize at the expense of the quality of service, and this is, after all, the purpose of all such contract requirements.

LETTERS TO THE EDITOR.

THE SEWAGE PRECIPITATION PLANT AT NEW ROCHELLE, N. Y.—CORRECTION.

Sir: We notice in your issue of Feb. 28 an article on the chemical precipitation plant at New Rochelle, N. Y., wherein you mention, amongst other materials having been used in this work, Taylor's American Portland cement. This is an error; it should read "Saylor's." We remain, yours truly,

Johnson & Wilson.

45 Broadway, New York, March 2, 1895.

SUBLIMED WHITE LEAD AS A PIGMENT.

Sir: Among the pigments used in painting wood and structural iron works, enumerated in recent articles on paints and painting in your columns, I find no mention of sublimed white lead, no doubt because it is a comparatively new pigment. Allow me to point out concerning this pigment that with oil it forms a remarkably smooth paint, far smoother than either red lead or corroded white lead; that it does not crack or peel; that it covers the surface with a perfect elastic coat that will stand the ordinary expansion and contraction of any metals, and that it will outwear any other lead paint, and is not acted on by acid gases. Iron painted with sublimed white lead, for many years exposed to the most severe tests, is in as good a state of preservation as the day it was painted, and the paint itself has suffered but very little decay.

Yours truly, C. V. Petraeus,

Joplin, Mo., March 5, 1895. Chemist.

STANDARD SIZES FOR CATALOGUES AND SPECIFICATIONS.

Sir: I am glad you are again calling attention to the matter of standard sizes for trade catalogues (editorial note in your issue of Feb. 21.) Coupled with the sizes for these I notice that there is also a standard size for specifications, viz., $8\frac{1}{4} \times 10\frac{3}{4}$ ins. I would be pleased to know what advantage this size has over the one which you advocate for catalogues, the 6×9 ins. I have been looking over some specifications which I have at hand and note the following sizes: Four 6×9 ins., and one each of the following sizes: $8\frac{1}{4} \times 10\frac{3}{4}$ ins., 7×10 ins., $5\frac{1}{4} \times 8\frac{1}{4}$ ins., $5 \times 7\frac{1}{4}$ ins., $4 \times 6\frac{1}{4}$ ins. It seems useless to lecture manufacturers, when engineers are the greatest aggressors. Yours truly,

W. O. Lellme.

(We presume the $8\frac{1}{4} \times 10\frac{3}{4}$ size for specifications has no better justification than the fact that a specification commonly forms part of a legal document, and therefore approximates to the well known "legal cap" size, which has been used by lawyers from time immemorial. The committee which adopted the standard sizes endeavored to conform as much as possible to customs already established; and a standard size for specifications departing materially from the time-honored legal cap size would probably be more honored in the breach than the observance. From the letters we receive from manufacturers informing us of their determination to conform to the standard sizes, we are of the opinion that it is by no means useless to "lecture" them. Really, it is a matter of far more importance to them than to the engineers. The manufacturers of the country spend many millions of dollars annually in catalogues. Anything which will induce customers to file and use these catalogues, instead of pestering the manufacturer with voluminous correspondence and calling for a visit from a traveling salesman for every little order, is of great importance to manufacturers.—Ed.)

THE SPECIFICATIONS FOR THE NEW YORK AND NEW JERSEY BRIDGE.

Sir: Are reasonable and bona fide bids likely to be secured on Mr. Theodore Cooper's specifications for the proposed New York & New Jersey bridge, published in your issue of March 7? In the first place, neither the New York & New Jersey Bridge Co. nor the New York & New Jersey Construction Co. have ever shown their financial solidity or standing. Secondly, the location of the bridge, as well as its design and detail, are subject to ratification and acceptance by not fewer than four parties, viz., the two companies mentioned above, the New York & New Jersey Bridge Commission and the Secretary of War. Thirdly, President Kerr, of the New York & New Jersey Construction Co., has said: "if it" (the bridge set forth in Mr. Cooper's specifications) "can be built within the estimate of $23,000,000 made by the government board of experts, we will at once proceed with the work."

The question is then, will any responsible contractor or bridge company spend months of study and labor, and go to thousands of dollars of expense, to furnish plans and estimates for a gigantic structure, the probability of construction of which is based on so many contingencies beyond the bidder's influence or control? It is to be noted that each intending bidder is obliged to file a "good" bond, satisfactory to a company which has never shown its own financial standing. As the location of such a bridge influences greatly the actual plans and costs, the contractor in making his bid must allow large margins for possible changes in the site, increasing the cost of construction. No reasonable estimate of the cost of a great bridge, such as the one under consideration, can be made unless it is based on an actual location, and unless shop drawings of a structure to occupy that location are worked out in minutest detail.

The specifications as drawn provide for a bridge of the heaviest type in general and in detail. They make provision for loads and strains which cannot possibly come on such a structure, and, moreover, all strains are provided for in the same manner as in truss bridges, which have but two carrying members, the failure of any one detail of which may cause failure of the entire structure. Mr. Cooper, in explaining his specifications, says: "Such a bridge should not be built for the present only, nor should a false economy cause the bridge to be designed and constructed upon the idea of restricting the speed, size, weight, or frequency of trains. In other words, you could not afford to tell any of these railways, by signals or otherwise, that another train could not be allowed upon the bridge because it was not built strong enough. The specifications are therefore drawn to rule out any plans which may be presented as cheap structures." This means that the specifications are purposely drawn to produce a heavy bridge, as is customary with Mr. Cooper in his practice as a truss bridge designer.

Again, these specifications take no account of the fact that the floor system, consisting of several longitudinal stiffening trusses and twelve lines of stringers, all rigidly connected to the floor beams, acts as a complete system of wind bracing. On the contrary, a system of the latter is called for, precisely as in truss bridges, where lateral distortion may easily be fatal. Besides all this, the heaviest type of structures are prescribed for stiffening trusses and floor systems, instead of permitting the use of those more economical in weight. The unit strains in the members are in almost all cases those which are customary in truss bridges, overlooking the fact that much greater strains are permissible in suspension bridges.

The kind of wire prescribed is such that it will produce neither the lightest nor the cheapest cables. Much stronger wire is readily obtainable in this country, as well as abroad, and at a price but little higher than the price of wire of the strength specified. It will be noticed that none of the wire, whether used for cables, wrapping, or for suspenders, is to be galvanized or protected against corrosion, except by being dipped in a proper coating of oil, which alone, however, is quite insufficient to prevent corrosion.

The loading on the bridge is taken as is customary in ordinary truss bridges, and the heaviest loads which could by any manner of means be placed upon the bridge are assumed as necessary to meet everyday demands. As the bridge immediately adjoins a terminal station, where arrival and departure of trains are always carefully arranged and speed of all trains is always under most perfect and complete control, it is absolutely impossible that the bridge itself will ever at any time be loaded throughout its length by trains of the heaviest type, and there can be no question that the number of trains on the bridge will be carefully regulated. The speed of trains can never reach the maximum provided for, as the bridge by the specifications must have a grade of more than 1¼%, and the trains in either direction either start from rest or come to rest within a mile of the bridge. Heavy trains cannot on such grades obtain high speed within a distance of several miles.

In view of the above array of facts, is it probable that a reasonable, bona-fide bid will be secured on the strength of these specifications? I venture to predict that but one bid may possibly be presented, and that by a party very much in interest and presented merely for the purpose of showing a suspension bridge to be vastly more costly than the estimates made by the several boards of experts who have heretofore carefully studied the problem. Yours truly,

Gus. C. Henning.

New York, March 12, 1895.

WIND PRESSURES IN ENGINEERING CONSTRUCTION.*

By W. H. Bixby, M. Am. Soc. C. E., Captain of Engineers, U. S. A.

1. As the question of wind pressures is now attracting the attention of engineers more than formerly, it is thought well to run over hastily the history of past experiments and past and present literature on the general subject of fluid motion against plates and solids, giving brief summaries of the most important sets of experiments (and reports on the same) which might be desirably referred to by any one wishing to examine further and in detail into such subject.

2. Since the accuracy of observations and also of deductions therefrom depend greatly upon the previous knowledge of each experimenter or writer, and also on the perfection of the methods and apparatus employed, it is quite important to bear always in mind the date of the experiments or treatises. Accordingly the following list is here inserted to show approximately the dates of such of the principal experiments or treatises as may either be referred to below or may be met in consulting other works on this general subject:

Year.	Experimenter or Writer.
1537	Tartaglio (ballistics).
1590-1638	Galileo.
1643	Torricelli.
1667	Hooke (pendulum anemometer).
1669	Mariotte.
1687	Newton.
1718-38	Daniel Bernoulili (fluids and ballistics).
1720	S. Gravesande.
1724	Leupold (gravity anemometer and tube anemometer).
1742-81	Robins (fluids and ballistics).
1744-52	d'Alembert.
1751	Rumford (ballistics).
1759	Rouse and Smeaton.
1760	Pitot (tube anemometer).
1763	Borda.
1775	Lind (tube anemometer).
1777	Bossut.
1780-6	Dubuat.
1780-90	Coulomb.
1783	Edgeworth.
1785-90	Woltmann.
1786-90	Hutton (fluids and ballistics).
1798	Vince.
1801	Eytelwein.
1802	Benzenburg.
1808	Venturoli.
1810-15	Swedish Commission.
1821-34	Beaufoy.
1826-8	Thibault.
1826-8	Bessel.
1826-51	Poncelet.
1827-9	Sabine.
1829-42	Duchemin.
1831	Rennie.
1832	Bailly.
1835-38	Piobert, Morin and Didion (at Metz) (fluids and ballistics).
1837	Osler (spring anemometer).
1846	Robinson (rotary cup anemometer).
1851	Stokes (treatise).
1855	J. B. Francis.
1861	Heile (ballistics).
1865-70	Bashforth (ballistics).
1867-70	Wenham and Browning.
1873-4	Hagen.
1873-8	Dohrandt.
1878	Robinson.
1878	A. M. Wellington (trains).
1880	London "Engineering" (on Tay Bridge).
1880-1	C. Shaler Smith (on bridges).
1880-1	Collingwood (on bridges).
1880-1	Am. Soc. Civil Engrs. (on bridges).
1880	Unwin (fluids) Encyclopedia Brittanica.
1880	Maitland (ballistics). " "
1880	Reckнagel.
1883	Schellbach.
1885	Thiesen.
1885	Ferrel (atmosphere).
1886	Allen.
1886	Hasen.
1887	Abbe (apparatus).
1887	St. Venant.
1888-9	Dines.
1890	Crosby.
1893	Langley.
1897	Kernot.

3. The usually recognized authorities on wind pressures to-day in engineering construction appear to be Poncelet in France (see par. 47), Unwin in England (see par. 47, and also article on Hydromechanics in last edition of Encyclopedia Brittanica), and Shaler Smith (see par. 28 and footnote 26) in the United States.

HISTORY OF PAST INVESTIGATIONS.

4. Newton.—Our general theoretical treatment of the resistance of plates to the motion of fluids against them dates back to the time of Galileo in 1590; but it was reserved to Sir Isaac Newton to give it practical form, which he did in his "Principia" in about 1687, in terms which are expressed to-day by the general formula $p = d\,a\,H^2 = d\,a\,\frac{v^2}{2g}$, in which p is the pressure per unit of surface, d is the density of the fluid, a is the maximum resisting area of the body in question, v is the velocity of relative movement of the fluid, g is the coefficient of gravity and $H = \frac{v^2}{2g}$ is the height required for gravity to give to a freely falling body the velocity v; the particles of the fluid being supposed perfectly free to move past each other in all directions. This formula, modified so as to apply specially to motions through air, becomes(1)

$$p = \frac{0.0027}{1 + .003665\ t}\ \frac{P}{P_1}\ v^2$$

in which p is the resistance in lbs. per sq. ft. of the exposed surfaces, t is the temperature in Centigrade degrees, P is the barometric pressure at the place of observation, P_1 is the barometric pressure at sea level on the 45th parallel of latitude when the temperature is zero Centigrade, and v is the velocity of the fluid or surface in miles per hour. This same formula, under temperatures of zero, and barometric pressures of sea level on the 45th parallel, further reduces to $p = K\ 0.0027\ v^2 = K\ \frac{1}{370}\ v^2$, in which K (equal to 1.0 in this particular case) is a constant introduced for comparison of Newton's theoretical formula with the later formulae of practice and experiment. In this shortened formula, the value of p must be decreased about 1% for each 4.5° Fahrenheit (each 2.5° Centigrade) in excess of the freezing point, and must be increased about 1% for each 0.36 ins. excess of barometric pressure above the normal of 27.795 ins. (760 mm.), with other minor corrections for latitude, height of apparatus above sea level, and dryness of air, at the place and time of experiment. The average conditions of barometer and thermometer in the middle of Europe and of the United States will therefore require these values to be decreased about 5% in fine summer weather, and increased about 10% in cold winter storms.(2)

5. Since the days of Newton, almost all investigators have sought, by practical experiments, either to prove the above theoretical formula or to determine the extent of the differences between theory and practice. Most of the differences so far proved have been merely those obtained by varying the values of K, leaving the formula otherwise unchanged. In the majority of cases of flat surfaces normal to moving air, K has been found to be somewhere between 1.3 and 1.8, the gain of from 0.3 to 0.8 being ascribed mainly to the effects of the partial vacuum on the rear side of plates and of solids exposed to the pressure of moving fluids. In some few cases, experiments have added a small constant so as always to give a result slightly in excess of that called for by $p = K\ 0.0027\ v^2$, and in still other cases they have also added terms to express variations with the first and third powers of the velocities, these formulae then taking the general shape of $p = A + Bv + Cv^2 + Dv^3$, in which A B C and D remain constant for the same surface and different values of v, some experimenters obtaining formulae in which A and D may be always zero, others obtaining those in which B and D may be zero, or A and B may be zero. In still other cases experimenters have added terms to indicate a change in the pressure per unit according to the outline, or else to the size, of the plate. However, such changes are the exception, and not the rule, and their necessity can hardly be regarded as yet proven; many of these changes having been recently found due partly or perhaps mainly to want of proper allowance for the errors or constants of the apparatus or methods used in the experiments.

6. The following brief summaries will show the general nature of these experiments and their results and will refer the reader to such printed reports and papers as might be of special interest to him, should he desire to go more fully into their examination.

7. Robins.—In 1742 Robins' experiments, with projectiles at high velocities, suggested to him the idea that the resistance varied with an increasing power of the velocity(3).

8. Rouse.—In 1759, a Mr. Rouse, in a paper read by John Smeaton(4), submitted to the Royal Society of England a table of wind pressures based mainly upon his own experiments with windmills, whose sails were moved bodily through the air by machinery, the resistances being deduced from the weights which either moved the wheel or were lifted by it during varying velocities of movement. Smeaton, in communicating the tables to the society, advised them that its resistances for velocities over 50 miles per hour did not seem as well authenticated as for those of less than 50 miles per hour. This table, which has been quoted as authority in numerous hand-books, text-books, and the U. S. Signal Service books, since then, gives results which may be deduced for any special velocity from the formula $p = 0.00492\ V^2$ or $p = \frac{1}{203}\ V^2$ (usually quoted for easy use as $p = \frac{1}{200}\ v^2$); this being deducible from the Newtonian formula by making K = 1.82.

9. Hutton.—In 1787-8, Hutton, in England, made some experiments(5) with thin plates of 4 by 8 ins. on whirling tables, from which he deduced the value $\sin a$ to the 1.842 cos a power for the ratio of the resistance (parallel to the motion) of thin inclined plates to that of similar plates turned normally to the direction of the motion, a being the angle between the plate and the direction of the motion. This formula gives values as follows: 1.00 for 90°; 0.99 for 80°; 0.96 for 70°; 0.87 for 60°; 0.72 for 50°; 0.52 for 40°; 0.33 for 30°; 0.16 for 20°, and 0.05 for 10°. (For values of pressures normal to the moving plate or normal to the direction of motion, see further on under head of Encyclopedia Britannica, 1880, par. 38.) His experiments, with projectiles under high velocities, suggested to him a formula for normal resistance of the form of $p = Av + Bv^2$; in which A and B were constants (see footnote 2).

10. Vince.—In about 1798, Samuel Vince(6) made a series of experiments as to the resistances of different surfaces to motion through water, using various plane and curved surfaces of about 1 in. square area, moving in circles of 7.57-in. radius on the bars of a small whirling table, the table being turned by a pair of equal weights pulling in opposite directions on two cords wound around a vertical drum on the vertical axis of rotation of the whirling tables. His results showed that in water and on whirling tables the resistances of surfaces in directions normal to their motion were closely proportional to the square of their velocity; that when the plane surfaces were inclined to the direction of their motion, the resistance in the direction of the motion varied somewhere between the sine and the $\sin^2$ of the angle of its inclination such that the resistance at 90° being taken at 1.00, that at 80° would be about 0.97, 70° about 0.92, 60° about 0.81, 50° about 0.67, 40° about 0.52, 30° about 0.33, 20° about 0.16, and 10° about 0.05; and that the resistance offered by the convex front of a hemisphere was only about 0.4 times that of its flat base front.

11. Thibault.—In 1828, Thibault also experimented with thin plates moved normally to their surfaces(6); using a whirling table of about 4.5 ft. radius, velocities of from 1 to 22 miles per hour, and plates of from 0.5 to 1.00 ft. square. His results gave formulae similar to those of Newton except that K varied from 1.66 to 1.90; being larger for the larger plates and also for those having their longer sides placed parallel to the radius of the whirling table.

12. Duchemin.—In about 1829, Col. Duchemin(7), in France, made some valuable original experiments and investigations on the laws of resistance of fluids, these results being published in 1842. In his published article he reviews the progress of similar investigations up to that time, referring to the experiments of Bernouilli in 1738, Rouse in 1759, Borda in 1763-7, Dubuat in 1780, Coulomb in 1780-90, Hutton in 1788, Samuel Vince in 1798, Venturoli in 1808, Thibault in 1826, and a dozen other investigators prior to himself. These experiments were made with all kinds of apparatus, falling bodies, swinging pendulums, whirling tables, towage, and exposure to currents; but the velocities rarely exceeded 20 miles per hour.

13. In this article he shows especially that as to resistances, the air acts almost identically as do water and other fluids, due regard being made for its less density, and freer fluidity; that the resistance of thin plates to being moved against fluids is only 0.62 of the pressure on their front surface, and only 0.67 of the pressure upon them when held still against the moving fluid; that the resistance of cylinders held end on to the direction of the motion, if three times as long as their diameter, is only 0.66 of that of their front face, being the same whether they or the fluid be in motion, but if shorter than three diameters, their resistances vary with this shortness and are much greater when the water is in motion than when the cylinder is in motion, so that for cylinders so short as to be called thin plates the resistance is 0.932 of that of their front face when the water is in motion and only 0.627 of that of the front face when the plate be moved against the water; that similarly-shaped surfaces moved with different velocities exert resistances closely proportional to the square of the velocities, to the densities of the fluid, and to the area of the surfaces; that these resistances are much affected by the shape of the front surface and a little by its size and outline, and in some way, though less, by the rear surface of the body or plate moved; that whirling tables (on account of the centrifugal forces brought into action) gave resistances much greater(8) than those obtained by the rectilinear movement of surfaces, this increase

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* Compiled by the author as Appendix "C" of the Report of Sept. 29, 1894, of the Special Army Engineer Board as to the Maximum Span Practicable for Suspension Bridges. Reprinted in Engineering News by special permission of the War Department.

(1) See Abbe, p. 246, Annual Report Chief Signal Officer, U. S. Army, 1887, in Part 2, Vol. IV., Annual Report Secretary of War, 1887.

(2) See Maitland, in article on Gunnery in Encyclopedia Britannica.

(3) For summary, see pp. 173-6, article by F. Collingwood, in Vol. 10, Trans. Am. Soc. C. E. for May, 1881; and full article, see Transactions Royal Society, England, 13 May and 14 June, 1759.

(4) See Duchemin, p. 216, Vol. 5, Mem. d'Artillerie, 1842; also Unwin, article Hydromechanics Encyclopedia Britannica 1880; also Langley, p. 63, No. 801, Smith. Contr. 1891.

(5) For items, see Duchemin, pp. 214 and 236, Vol. V., of Memorial d'Artillerie, 1842, and Abbe, p. 234, as above; and for full article see Philosophical Transactions 1798.

(6) See Abbe, p. 234, as above.

(7) See pp. 65-230, Memorial d'Artillerie, Vol. V., 1842.

(8) See p. 206, as above.

being the greater as the surfaces were larger and the diameter of the whirling table smaller; that small surfaces gave slightly greater resistances per unit of surface than similarly-shaped large surfaces; that lead bullets, by deformation or through other causes, at high velocities of 15 to 900 miles per hour, gave results far in excess of the true resistances(9); and that inclined surfaces gave resistances which were considerably in excess of the product of the pressure on non-inclined surfaces by the sine of the angle of inclination.

14. The most important laws thus brought out by Duchemin are expressed by him in formulae which, after reduction to English measures, read as follows: For ordinary air pressures on thin stationary plates(10) $p = 0.00942\ v^2 = \frac{v^2}{203}$ (p being the pressure in lbs. avoirdupois per sq. ft. and v the velocity in miles per hour), this being the Newtonian formula except that K = 1.82; for pressures on circular and triangular flat thin plates practicallly the same results as for square plates; for air pressures on inclined flat thin plates, $p = 0.00492\ v^2 \frac{2 \sin^2 a}{1 + \sin a}$, for the pressure parallel to the wind, $0.00492\ v^2 \frac{2 \sin a \cos a}{1 + \sin^2 a}$, for lifting or depressing pressures perpendicular to the wind, and $0.00492\ v^2 \frac{2 \sin a}{1 + \sin^2 a}$ for pressures normal to the surface(11), a in each case being the angle between the wind and the surface (for values for each 10 degrees, see further on under head of Encyclopedia Britannica, 1880, par. 38); for spherical(12) headed surfaces, 0.4, and cylindrical(13) headed, 0.6 of the pressure on flat plates of the same diameter; for conical and wedge-headed surfaces pointed at the wind(13), $p = 0.00492\ v^2 \sin^2 i$, in which i is the angle between the wind and the conical surface or between the wind and the sides of the wedge; and for stationary flat-headed but solid cylindrical bodies(14), less pressures amounting to 80, 72 and 71% of the pressure on thin flat plates according as the length of the solid bodies was 1, 2 and 3 or more times their front diameters.

15. Duchemin also refers, as with importance, to the supposition first advanced by d'Alembert(15), in about 1750, and afterwards developed more fully by Dubuat, in about 1780, that plates and solid bodies in moving fluids and especially under high velocities act as if they were partly protected in front by a false prow made up of compressed articles of the fluid itself.

16. Piobert, Morin, Didier, at Metz.—In 1835-8, a commission of French officers, composed of Piobert, Morin and Didion, made at Metz a series of experiments(16) with whirling tables, falling bodies and flying bullets through both air and water, at both low and high velocities.

17. Their results seemed to indicate a pressure slightly in excess of that due to the square of the velocity and gave a formula(17) for thin flat plates exposed to air pressures, $p = 0.0073 + 0.0034\ v^2$ (p in lbs. and v in miles per hour); which, however, at velocities of over 10 miles per hour returned practically to the old Newtonian formula except that K = 1.25. Amongst other results they found for wedge-headed projectiles(18) the pressure equal to that on flat heads multiplied by $\frac{a}{90}$, in which a is the angle between the wedge surface and the direction of the motion; for parachutes(19) whose height was 0.3 of their diameter, a pressure in ordinary position 1.9 times and upside-down 0.77 times that on flat plates of the same diameter; and for spheres(20) only 0.15, for cubes 0.65, and for long cylinders 0.30 times the pressures on thin disks of the same diameters.

18. Later experiments with projectiles, in 1840, suggested to Didion the usefulness for normal resistances at high velocities of a formula $p = Av^2 + Bv^3$, in which A and B were constants. (See footnote (3).)

19. U. S. Ordnance Corps.—The U. S. Ordnance Manual of 1861 gives(21) for the then standard formula for the resistance of air to projectiles a French formula of $p = 0.0011\ v^2 (1 + \frac{1}{103} v)$ for spherical projectiles, which would by inference give $p = 0.0022\ v^2 (1 + \frac{1}{109} v)$ for flat-headed projectiles, in which p is in lbs. per sq. ft. and v in miles per hour; this latter formula for flat heads being the Newtonian formula, with K = 1.80 for velocities of 22 miles per hour, K = 1.25 for 51 miles velocity, K = 1.50 for 100 miles velocity, and K = 1.80 for 130 miles velocity. The main difference between this formula and others is therefore simply that it gives for low velocities a less pressure than is deduced from the mass of experiments with low velocities, leaves the pressure at velocities between 100 and 130 miles approximately those of the other most usual formulae, and gives rapidly-increasing pressures for velocities of over 130 miles.

20. Helie.—In 1861, Helie, from experiments with projectiles, concluded that the normal resistance at high velocities was best expressed by a formula of the form of $p = Av^3$, in which A was a constant. (See footnote (7).)

21. Bashforth.—In 1865-70, Bashforth, from experiments with projectiles, concluded that the normal resistance at high velocities was best expressed by the formula $p = Av^2$, up to values of v = 1,100 ft. per second (about 750 miles per hour); then, by $p = Bv^3$ up to values of v = 1,350 ft. per second (about 930 miles per hour); and then by $p = Cv^3$ for higher velocities, in which A, B and C were constants. Modern ballistics in England is still (1894) based upon these formulae. (See footnote (21).)

22. Wenham and Browning.—In 1867-70, Wenham and Browning made some experiments for the London Aeronautical Society with plates of 1.0 to 2.0 ft. square, placed in a wind blast issuing from an 18-in. square pipe under a 0.6 to 1.0-in. water pressure.(22) Their experiments tended to confirm Duchemin's formula for normal, parallel and lateral pressures on inclined thin plates.

23. Wellington.—In 1878, A. M. Wellington, at or near Cleveland, O., made an extensive set of experiments(23) with locomotives, cars and different grades or slopes of railway track, in order to determine all the various resistances to the haulage of trains, making use of the drop test—that is, starting the cars from a state of rest on a known grade and deducing the resistances from the velocities acquired. The passage of the trains past 11 different points was noted by electricity to within 1-20 of a second, the experiments covering velocities from 0 to 30 miles per hour.

24. So far as the air resistances were concerned, the results of these experiments were to show that for velocities of 10 miles per hour, p is less than $\frac{1}{500} v^2$ (less than $0.0020\ v^2$), for the combined head resistance and tail suction of a train whose cross-section was 10 × 14 = 140 sq. ft.; and p is less than $\frac{1}{4,500} v^2$, (less than $0.00023\ v^2$), for the combined side and end resistance of each succeeding car, the gaps between the ends of two adjacent car bodies being 6 ft., p in these formulae being the resistance of the air in lbs. per sq. ft., and v the velocity in miles per hour—so that the formula becomes that of Newton, with K = 0.74.

25. In these experiments, he also discovered that fully half the previously reported air resistance in such cases was not really due to air pressure, but was due to the effects of oscillation and concussion between the various individual parts composing the entire train. The remarks of Mr. Wellington give rise to the inference that similar friction, oscillation and concussion in whirling tables and other apparatus may be the cause of the high values of the constants deduced from such past experiments. This suggestion, moreover, is evidently in accord with conclusions of many other investigators.

26. London "Engineering."—In about 1880-81, just after the fall of the Tay Bridge, the matter of wind pressures naturally attracted the special attention of bridge engineers of England as well as of the United States, and the London "Engineering" of 1880-1 contains very numerous articles and discourses on this subject, with special reference to its relation to bridges and other engineering structures. These articles are too numerous to itemize; but their most important features are the wide divergencies of opinion between engineers both as to the amount of such pressures, the allowance to be made for them, and the methods of calculating the supposably exposed surfaces of the structures.

27. Tay Bridge Commission.—Probably the most valuable part of these discussions is the recommendation of the Tay Bridge Commission of 1881(24) which may be briefly stated as follows: On solid girder bridges, an allowance of 56 lbs. per sq. ft. over all the girder (and also over as much of a train as may rise above the girders); and on open or lattice girders, an allowance of 56 lbs. per sq. ft. over the train and over the actual area of iron work of so much of the windward girder as projects above or below the train, and also an allowance of 28, 42 or 56 lbs. per sq. ft. over the actual area of the iron work of the like projecting portions of the leeward girder, according as the open spaces of this leeward girder form less than ⅔, from ⅔ to ¾, or over ¾, respectively, of the total area of the outline of the girder. The factor of safety against such pressures should be 4 against tension and compression, and 2 against overturning. The same committee also stated their opinion(25) that the pressures to be expected from winds of any given locality might very nearly be expressed by the formula, $p = \frac{1}{100} v^2$, in which p is in lbs. per sq. ft., and v is in miles per hour, as given by the usual cup velocity anemometer records of that locality.

28. Shaler Smith and Am. Soc. Civil Engineers.—In 1880, Messrs. A. Welch, C. Shaler Smith and F. Collingwood, read papers upon the general subject of wind pressures before the American Society of Civil Engineers(26), and Mr. Smith submitted a summary of his personal observations of the force and action of wind and tornadoes upon bridges and structures, adding a statement of the rules followed by him in his own bridge practice. These papers, with their discussion before the society, give the reasons for the present ideas and practice of American bridge engineers. The most important features of these papers are the many descriptions by eye-witnesses of the force and violence of the wind in actually overturning houses, water-tanks, bridges, and even locomotives, the small width of the path of most violent action, the varying ideas of the pressure actually necessary to produce these results, and the practical rules submitted by Mr. Smith as to what he deems necessary allowances for wind pressures.

29. The most violent records of wind force thus given were: The blowing down of three bridges (between 1866 and 1880), at computed pressures of from 18 to 27 lbs. per sq. ft.; several cases of train derailments at computed pressures of 30.5 lbs. per sq. ft.; the destruction of brick houses at computed pressures of from 58 to 84 lbs. per sq. ft.; the overturning of a barrel of tar at a computed pressure of 52 lbs. per sq. ft.; the overturning of a locomotive at a computed pressure of 93 lbs. per sq. ft.; the lifting of a piano, transporting it 270 ft. and then replacing it on its feet without apparent injury; the bursting of houses by blowing outward their ends and sides; and the perforation of a half-inch pine board (originally the side of a dwelling house) by wheat straw flung against it end first (by a Wisconsin tornado).

30. As to the upward tendency of the wind through the bottom of the bridge, enough evidence was presented to suggest the decided advisability of not making the flooring continuous unless so left as to be easily ripped up by the wind without carrying the rest of the bridge with it.

31. As to the actually observed velocity and force of the wind, as measured by anemometers, the discussion brought out the records of the Bidston Observatory, near Liverpool, England, showing isolated cases of 92 miles total velocity in a single hour and 80 lbs. per sq. ft. maximum pressures in 1868, 82 miles velocity and 65 lbs. pressures in 1870, 79 miles velocities and 90 lbs. pressures in 1871, 81 miles velocity and 70 lbs. pressure in 1875, 80 miles velocity and 64 lbs. pressures in 1877, and 59 miles velocities and 38 lbs. pressures in 1879; the velocities being measured by Robinson cup anemometers (giving only the totals per hour), and the pressures being measured by Osler spring pressure anemometers (giving maximum, and not average, pressures); but it was also stated by a resident of that place that these velocities and pressures must have been of limited extent and duration, as no houses nor cars nor freight trucks appeared to have been blown over or damaged by these same winds(27).

32. As regards the destruction of the Tay Bridge, the discussions show that the London Engineering (or Engineer) of 2d January, 1880, computing the exposed surfaces of the bridge as being that of the windward girder, plus that of the train, plus also 0.5 that of the lee girder, deduced a possible pressure of the wind of from only 23 to 36 lbs. and expressed the belief that the maximum pressure did not exceed 25.5 lbs. Others, basing their computations on the non-destruction of the adjacent signal boxes, etc., deduced pressures of from 15 to 40 lbs. The doubtfulness of deductions from the exposed surfaces of the bridge is evident, however, from the fact that such surface as measured by Shaler Smith, according to his American rules, was 2,576 sq. ft. against only 800 sq. ft. as measured by English engineers, or as 3.2 to 1.0; so that definite results and accord cannot be expected

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(9) See p. 270, same.
(10) See pp. 300-2, same.
(11) See p. 213, same.
(12) See p. 237, same.
(13) See pp. 248-253, same.
(14) See p. 76, same.
(15) See p. 336, same. This idea has been strengthened in the last few years by the appearance of the waves of compression in air in front of flying bullets, as shown in recent instantaneous photographs of such bullets.
(16) For full details, see pp. 533-632, same; and pp. 197-292, Vol. VII. (1852), of the Memorial d'Artillerie.
(17) See p. 279, Vol. VII., same.
(18) See p. 291, same.
(19) See p. 289, same.
(20) See p. 237, same.
(21) See p. 482, same.

(22) Unwin, Encyclopedia Britannica, 1880, article Hydromechanics; also p. 244, Abbe on Meteorological Apparatus, 1887; also Annual Report London Aeronautical Soc., 1871.
(23) See pp. 493, 518, 522, and 911, Railway Location, A. M. Wellington; and for full article, see Transactions Am. Soc. C. E., February, 1879.
(24) See Burr, Stresses in Bridge and Roof Trusses, p. 368; and Fidler, Bridge Construction, p. 416.
(25) See Burr, p. 370.
(26) See pp. 391-400, Vol. IX., October, 1880, and pp. 139 to 186, Vol. X., May, 1881, Trans. Am. Soc. Civil Engineers.
(27) See later on, as to 40% reductions to be applied to the small plate pressure records to give pressures on large surfaces, and the 25% reductions to be applied to all cup rotary anemometers.

unless the various computers will agree better as to what constitutes the so-called exposed surface of a bridge.

33. As to the width of path of the greatest violence of tornadoes, Mr. Smith having followed up the path of several cyclones, found but one case where 60 ft. width was not sufficient to cover the pathway within which the computed pressures exceeded 30 lbs. per sq. ft.; and numerous instances were given by others to show that in their opinion even the gusts of both ordinary and severe winds were of very limited reach in side directions. Moreover, a cyclone, whose center actually crossed a 320-ft. length span of railroad bridge, showing maximum pressures of at least 52 lbs. per sq. ft. at one point on the bridge and 84 lbs. per sq. ft. elsewhere, did not destroy this span, although its wind bracing had been built by Mr. Smith with allowances of only 30 lbs. wind pressure per sq. ft. of exposed surface and of 20,000 lbs. per sq. in. strain on the braces.

34. However the most important feature of these papers is the set of empirical rules used by Mr. Smith in dimensioning wind bracing on high and exposed bridges, which may be briefly stated as follows: Spans must be proportioned to stand a horizontal wind pressure of either 30 lbs. per sq. ft. on both structure and train, or else 50 lbs. on the structure alone, using whichever of these pressures is the greatest. In measuring the structure, both trusses are to be measured, using 1.5 times the front surface of ties, 2 times that of chords, and 1.0 times that of the other parts of the truss; and the train is to be considered as a continuous front of 10 ft. height over its full length. The train pressure is moreover to be treated as a moving or live load and the truss pressures as dead loads. Stresses are to have a factor of safety of 4. Piers are to be proportioned in the same general way as spans; except that they shall be given a base broad enough to prevent any tension strains in their columns. If the bridge is on a curve, the spans and piers must be proportioned to stand a centrifugal force due to the maximum load moving at 40 miles per hour, in addition to the wind strains. In addition to all the above, an allowance of 10,000 lbs. in each member must be made to provide for the initial stress produced in screwing up rods during the final adjustment of the bracing.

35. In support of the above views, Mr. Smith and others expressed opinions that 30 lbs per sq. ft. wind pressure rarely, if ever, extended over more than 60 ft. continuous horizontal length at one time and place; that even this wind was but rarely directed squarely against the side of a bridge; that in the case of at least one bridge he has assured himself of the whole bridge having received as much as 1.8 times the wind pressure on one truss; that as fully-loaded passenger and freight trains would leave the track at pressures of 31 and 56 lbs. per sq. ft., and as then the bridge would be destroyed by derailment, it was useless to protect it against heavier pressures under train loadings; that with no tension in the piers under 30 lbs. per sq. ft. wind pressure, the piers would safely stand all excess pressure that might come upon it; and that even if the bridge were over-strained occasionally by wind pressures, such cases would be so rare and the fatigue of metal so slight that the material resisting this strain would not be seriously injured.

36. Unwin and Greenhill and Encyclopedia Britannica.—The new edition of Encyclopedia Britannica (in Vol. XII., published about 1880) contains an article on Hydromechanics, by Unwin and Greenhill, which may fairly be regarded as representing English ideas of that date.

37. In this the relations of pressure and velocity are given by the Newtonian formula, with K = 1.3 for plates moving in still air or water, and with K = 1.8 for water or air moving against still plates.

38. The pressure of horizontally moving air, on thin inclined plates is stated at either $H = P (\sin a)$ to the 1.842 cos a power according to Hutton, or as $H = P \frac{2 \sin^3 a}{1 + \sin^2 a}$, $L = P \frac{2 \sin a \cos a}{1 + \sin^2 a}$, and $N = P \frac{2 \sin a}{1 + \sin^2 a}$, according to Duchemin, in which H is the horizontal resistant, L is the lateral resistance (or resistance to lifting or sinking), $N = \sqrt{L^2 + R^2}$ is the normal resistance, P is the pressure on the same plane when normal to the motion of the air, and a is the angle between the wind and the inclined surface. (See also Hutton, par. 9, and Duchemin, par. 14.) From Duchemin's formula for H, the pressures, parallel to the wind, become: 1.00 for 90°; 0.99 for 80°; 0.94 for 70°; 0.86 for 60°; 0.74 for 50°; 0.59 for 40°; 0.40 for 30°; 0.21 for 20°; and 0.06 for 10°. From Duchemin's formula for N, the pressures, normal to the inclined plate, become: 1.00 for 90°, 80° or 70°; 0.99 for 60°; 0.97 for 50°; 0.91 for 40°; 0.80 for 30°; 0.61 for 20°; and 0.34 for 10°. From Duchemin's formula for L, the lateral (lifting, depressing or side moving) pressures normal to the wind become: 0.00 for 90° (where the plane is normal to the wind); 0.17 for 80°; 0.34 for 70°; 0.50 for 60°; 0.63 for 50°; 0.70 for 40°; 0.70 for 30°; 0.58 for 20°; 0.33 for 10°; and 0.00 for 0°, (where the plane is parallel to the wind). For angles of from 90° to 50°, the Hutton and Duchemin formulae for H, N and L give results in accord with each other to within 0.02.

39. Ferrel.—In 1885, William Ferrel, of the office of the Chief Signal Officer, U. S. Army, prepared an extensive report[28] on meteorology in general, based upon meteorological research and observations from all over the world during the preceding 25 years, giving a thorough theoretical discussion of the whole subject of atmospheric conditions and movements, together with many practical illustrations. The chapters on cyclones and tronadoes contain much matter of special interest to the subject of wind pressures in general. Numerous bibliographical references make the report of much additional value to those studying this subject. Amongst other things, the following of his statements are specially interesting in connection with our present investigation:

40. The normal atmospheric pressure being 14.7 lbs. per sq. in., or over 2,100 lbs. per sq. ft., it is not surprising that small differences of barometric pressures may cause winds of high velocities and great pressures. If the barometric pressure in a tornado be 3 ins. below the general pressure (which has sometimes been the case in the past), the resulting wind may have a velocity of over 300 miles per hour and a pressure of over 240 lbs. per sq. ft. Moreover, if the center of such a tornado passed suddenly over a building with closed windows and doors, the sudden expansion of the air in the building due to this 3 ins. differences of barometric pressure might reach 211 lbs. per sq. ft. of surface, plenty enough to blow cellar doors from their fastenings, blow out windows and ordinary doors, burst out walls, blow up roofs, and wreck buildings generally, as is known actually to have been done. Such an example as this is by no means an extreme supposition, for it is possible for the differences of barometric pressures in tornadoes to be twice as much as this, and even more. In the great storm of 26th January, 1884, in Scotland, a reading of the barometer near Crieff showed only 27.222 ins.[29] when reduced to sea level, and in this case the difference of barometric pressures between its center and some points within the area of the storm must have been at least 3 ins. In the hurricane of 24th January, 1868, also in Scotland, barometric observations at Aberdeen and Culloden showed an actual difference of 1 in. in 138 miles, accounting easily for extended wind disturbances with velocities of from 71 to 93 miles[30]. These two actually-observed cases are merely cases of cyclones or severe but general storms extending over large areas. In the cases of tornadoes, which are more local, and at the same time more severe within their small area, these differences of barometric pressure, and the consequent wind velocities and wind pressures, may be very much greater. In 600 tornadoes observed in the United States (see Prof. papers No. 7, U. S. Signal Service by Finley) the width of the path of destruction, supposed to measure the disturbance between the areas of sensible winds on the north and south sides of the storm's center, varied from 40 to 10,000 ft., the average being 1,085 ft.[31]. Under the most favorable circumstances (when over deep and narrow valleys) 1.2 ins. of low barometer in the middle of a tornado might give to the ascending current of air a velocity of as much as 57 miles per hour [32]; but, ordinarily, on fairly level ground, this velocity would be much less by reason of the friction of the incoming air upon the adjoining earth surface around the tornado center.

41. As to the relation between velocities and pressures of air on varying surfaces, the discussions of pure theory indicate that horizontal winds should give horizontal pressures of $p = 0.0027\ v^2$ against vertical plane surfaces normal[33] to the wind, in which p is the pressure in lbs. per sq. ft. of the exposed surface, and v is the velocity in miles per second, strictly according to the Newtonian formula, with K = 1; and that this pressure should be multiplied by 0.66 for horizontal pressures against vertical cylinders[33] by 0.50 against spheres[33], by $\sin^2 a$ for horizontal pressures against inclined vertical plane surfaces, and by sin a for the normal pressures and sin a cos a for the lateral pressures on such planes[34], a being the angle between the wind and the plane. In all these cases, p must of course[35] be decreased about 1.0% for each 4.5° Fahrenheit excess of temperature above the freezing point, and must be increased about 1% for each 0.36 in. excess of barometer reading above the normal 27.795 ins., with other slighter corrections for latitude and height of apparatus and dryness of air at the place and time of the experiments. However, the values obtained from the above theoretical formulae should all be increased in order to give results in accord with actual experiment, this increase for thin square plates[36] normal to the wind being perhaps as much as 35%, giving $p = 0.00365\ v^2$ or $p = \frac{v^2}{274}$ (with perhaps other lesser variations according to the shape and size of the plate), and this increase for hollow spheres[37] of 1 sq. ft. maximum cross-section being perhaps as much as 10%, giving $p = 0.002\ v^2$ or $p = \frac{v^2}{500}$; such increase being probably due to the effects of air-friction and other minor causes not allowed for by the Newtonian formula, and to the effects of friction, oscillation and inertia of apparatus not completely allowed for by the experimenter.

42. Attention is also called to the fact that the actual velocity of wind must necessarily vary very greatly according to its altitudes above the ground and also above sea-level, according to the proximity and shape of the adjacent hills and valleys, and must almost invariably on land be also exceedingly variable from moment to moment; and to the fact that the values of wind velocities and wind pressures as deduced from the records of the most used anemometers may often be very greatly in error, the ordinary cup anemometer with a coefficient of 3.0, while approximately correct for light winds of from 5 to 10 miles per hour, giving (unless specially corrected therefor) velocities from 20 to 25% too large for winds of 25 to 30 miles recorded values and perhaps greater excess errors for winds of still higher velocities[38].

43. Hazen.—In 1886, H. Allen Hazen made a set of original experiments in Washington[39], with a whirling bar, using plates from 4 ins. to 2 ft. square, moved in circles of 4, 8 and 16 ft. radius, with velocities of from 4 to 16 miles per hour, in a closed room about 50 ft. square, having, however, only about 40 sq. ft. of clear space. The plates were hung from the ends of the bar by delicate threads of from 4 to 8 ft. length so as to swing freely back under the air pressure, the bar was turned by the untwisting of ropes, the revolutions of the bar were recorded by a chronograph, and the resistances were computed from the observed angular swing of the plates under the air pressure, the extent of swing being noted by an observer standing at the center of revolution. The experiments with 16-ft. radius circles gave no signs of increased pressures for the larger plates. In addition to using the results of his own experiments, Mr. Hazen consulted the work and the results of Borda in 1763, Piobert, Didion, and Morin in 1835, Hagen in 1873, and compared his results with theirs with final conclusions as follows: That for velocities up to 7 miles per hour with small plates, and up to 4 miles per hour with large plates, $p = 0.0034\ v^2 = \frac{v^2}{295}$, in which p is the pressure in lbs. per sq. ft., and v the velocity in miles per hour; this being the Newtonian formula, with K = 1.25; that the increase of pressures heretofore ascribed to large plates is mainly due to the centrifugal forces of the whirling tables; that for accurate results in such matters, the whirling tables must be of greater radius than 16 ft., and that pressures for higher velocities need special further experiment. As the radii of the whirling tables used by Vince were less than 8 ins., those by Thibault less than 5 ft., those by Borden and Hagen less than 8 ft., while those of Hazen were as great as 16 ft., Mr. Hazen's conclusions are entitled to special consideration as regards the increased length of radius of whirling tables necessary to secure reliable results.

44. Abbe.—In 1887, Cleveland Abbe, of the office of the Chief Signal Officer, U. S. Army, prepared an extensive report[40] on meteorological apparatus and methods. The chapters on measures of wind velocity and on anemometers are of special value in relation to the subject of wind velocities and pressures, as they contain careful descriptions of all the most used air-velocity and air-pressure apparatus, and equally careful digests of all past work, in connection with the determination of their possible errors and their constants. Chapter 12 contains a theory of vanes, with descriptions of those most used in determining the directions of the horizontal and vertical components of the wind. Chapter 14 contains tables of the scales of wind velocities as used by various foreign nations, and their comparison with that of the International Bulletin as now published by the U. S. Signal Service. Chapters 15, 16 and 17 contain a theory of anemometers with descriptions of the various direct-pressure anemometers (the pendulum or swinging plate, the normal plate and the tubular), the suction anemometers (with horizontal tubes and with vertical tubes), and the rotation anemometers (windmills, screw propellers, and cups). Incidentally also to the discussion of the theory of such anemometers, these chapters contain a brief but careful description of the

[28] See Ferrel, pp. 1-443. Part 2, Vol. IV., Annual Report, Secretary of War, 1885.
[29] See p. 255, same.
[30] See p. 285, same.
[31] See p. 288, same.
[32] See p. 312, same.
[33] See p. 305, same.
[34] See p. 298, same.
[35] See p. 302, same.
[36] See pp. 407-8, same.
[37] See pp. 305 and 315, same.
[38] See pp. 403-8, same.
[39] See pp. 241-248, Vol. CXXXIV., Am. Journal of Science, 1887.
[40] See Abbe, pp. 1-392, plates 1-36, Part 2, Vol. IV., Annual Report Secretary of War, 1887.

various experiments of Mariotte, Woltmann, Dubuat and Thibault, as to the pressure of moving fluids on stationary solids; and of Mariotte, Newton, Benzenburg (with falling bodies), of Robins, Hutton, Bashforth, Mayevski (ballistic pendulum), of Bouguer, Borda, Ulloa, Buchanan, French Commission, Swedish Commission of 1810-15, Dubuat, Piobert, Morin and Didion (towage through water), as to the resistance of a stationary fluid to a solid moving rectilinearly through it; and of Robins, Schober, Rouse, Borda, Coulomb, Edgeworth, Hutton, Vince, Thibault, Beaufoy, Rennie, Prechtel, Dobrandt, Hagen, Rechnagel, Schellbach and Thiesen, as to the resistance of a stationary fluid to a solid moving circularly through the fluid (water or air) by the use of whirling tables of some sort; and of Borda, Dubuat, Coulomb, Bessel, Sabine, Baily and Stokes, as to the resistance of a stationary fluid to both swinging and revolving spherical pendulums. From these descriptions and discussions the following items are selected as of special interest in connection with wind pressures and velocities.

45. In order to obtain reliable results from the comparisons of the records of various experiments, great accuracy is necessary as to the conditions under which these experiments were made and as to the constants so-called of the apparatus used; but in matter of fact, a large proportion of the more accurately-made experiments are not recorded in such way as to be accurately comparable with each other. The temperature effects are often quite great, but such observations are not always taken, and even then are often not reliable to within 1 or 2°. The measures of the wind directions are often erroneous to several degrees, and the wind velocities and pressures to large per cents., from mere absence of continuous automatic records showing the variations at short intervals. The constants by which the displacement records of the pendulum pressure anemometers[41] are converted into lbs. per sq. ft. may be easily erroneous to 10% in ordinary winds, and more in high winds; those of the normal pressure plate[42] anemometer may occasionally be erroneous to as much as 10% at ordinary velocities though the improved forms of the Osler anemometer reduce this percentage very greatly; those of the most used velocity[43] anemometers (the Robinson hemispherical cup anemometer, usually assumed to rotate with one-third the velocity of the wind) may, unless each anemometer be carefully compared with the standard, easily be erroneous to from 15% for low velocities up to 25% for high ones, since the ratio between the actual velocity of the wind and the revolution of the anemometer varies with the size of the cups, the lengths of the arms, the total weight and inertia of the moving parts, the surfaces of friction, the density of the outside air, and finally the velocity of the wind. Heavy anemometers of the pressure plate or rotary cup form, may also by the great inertia of the moving parts, show much larger instantaneous pressures and much greater hourly velocities than actually exist. Moreover, it is to be remembered that all these pressure and velocity anemometers as ordinarily used show only the horizontal component of the wind, and not its total force. We must always therefore bear in mind that many allowances must be made for the errors of apparatus of all kinds and that reports of past and present work must be judged accordingly.

46. As to the general direction of winds on land, statements have been made[44] that the wind, in Europe at least, has a general downward inclination of from 10° to 20°; but it does not seem likely that this is anything but the effects of occasional and strong gusts, so that except for such gusts the direction of the wind may be assumed as ordinarily horizontal.

47. As to the relation between pressures and velocities, the evidence so far seems to be still decidedly in favor of the use of the Newtonian formula (with proper coefficients for K) in preference to all others yet suggested. For the case of solids moving through stationary liquids, the evidence up to 1887 seems to be in favor of K = 1.3, which for the pressure on thin plates, when moving through stationary air, would give $p = 0.0035\ v^2$, or $p = \frac{v^2}{285}$ (subject to the usual modifications (see footnote (1)) for temperature, barometric readings, and latitude), in which p is in lbs. per sq. ft., and v in miles per hour (equivalent to $p = 0.0075\ v^2$, or $p = \frac{v^2}{613}$ if p be in lbs. and v in ft. per second); and this relation is indorsed by Poncelet in France and Unwin in England[45]. For the case of liquids moving against stationary solids (as winds against anemometers, houses and bridges) the evidence up to 1887 seems to show a value of K somewhere between 1.3 and 1.85, and nearer 1.85 than 1.3; so that for apparent fear of under-estimation, Poncelet in France and Unwin in England indorse the use of K = 1.85, with a suggestion that more accurate experiments are still needed[46]. For K = 1.85, the Newtonian formula, in the case of air striking normally on stationary thin plates, would give $p = 0.0050\ v^2$, or $p = \frac{v^2}{200}$, in which p is in lbs. per sq. ft., and v is in miles per hour (or $p = \frac{v^2}{450}$ if v is in ft. per second); this being also practically the same as the Rouse-Smeaton formula of 1759, which is that adopted by the U. S. Signal Service in its work in connection with the preparation of the International Bulletin of Meteorology[47]. As to the differences between pure theory and actual practice, in the above cases, it is at present impossible to decide whether the differences between K = 1.3 and K = 1.85 for moving plate and moving fluid are due to errors of observation or represent laws of nature, but it may be fair to assume for them equal weights and take K = 1.66 as a common factor applicable alike to both cases[48]. The experiments of Dubuat showing by actual direct measures that the vacuum on the back of the plate, due to imperfect fluidity or imperfect continuity in the disturbed fluid, added 0.433 units of pressure to each 1.0 unit of direct pressure on the front of the plate[49], are in thorough keeping with the above assumption. For K = 1.66, the Newtonian formula, in case of air on thin plates, either being stationary, would give $p = .0045\ v^2$, or $p = \frac{v^2}{222}$, in which p is in lbs. per sq. ft. and v in miles per hour. However, this value is not yet indorsed by Poncelet, Unwin and other engineering authorities.

48. As to the determination of such relations up to 1887 by falling bodies, by the ballistic pendulum, and by flying bullets, the results, while of use for purposes of comparison amongst themselves, are hardly accurate enough for use in determining the direct relation of pressure to velocity.

49. As to the use of whirling machines in determining fluid pressures on flat surfaces, it appears that the experiments of Borda, Robins, Vince, Coulomb, Hutton, Edgeworth, Beaufoy, Rennie, and Hagen (all that are quoted as made prior to 1886), were made with small plates of only from 0.01 to 0.30 sq. ft. area, in circular paths of only from 0.6 to 8.0 ft. radius, with velocities of only from 0.6 to 16 miles per hour so that their results must be regarded as somewhat doubtful even for velocities of 16 miles per hour, and certainly quite doubtful for greater untested velocities[50]. Moreover, the experiments of Scott in 1872, Robinson in about 1873, Dohrandt in 1873-7-8, and Stelling in 1882, with the Robinson cup rotary anemometer, whirled on tables of from 9 to 10 ft. radius, with from 7 to 42 miles per hour velocity (in endeavoring to determine the constants of the Robinson rotary anemometer), showed at times the existence of induced circular currents of from 1 to 2.2 miles per hour velocity in the air adjacent to the edge of the whirling table (from 10% to 7.5% of the velocity of the edge of the table, according as this latter velocity varied from 10 to 30 miles per hour), showed also the existence of decided radial currents whose amount and effect have not yet been thoroughly discussed and allowed for, and gave much other good evidence that the history of past experiments with small whirling machines is not to be greatly relied upon except so far as it is confirmed by other more reliable testimony; and that reliable results are not to be obtained in this way in the future except by the use of much larger machines and many further precautions against errors of the apparatus[51].

50. Although almost all experimenters feel certain that the pressure per unit on large surfaces must be much less than on smaller ones[52] and that the shape of the perimeter of the surface must also to some extent influence the pressure on the plate, still the law of such variation is not yet satisfactorily determined[53]. The formula of Hagen (1874) is regarded as the latest and best of its kind, but its value is diminished by the fact that it was deduced from the movement of plates of only from 0.02 to 0.30 sq. ft. area, moved at velocities of only from 1 to 4 miles per hour, on a whirling table of only about 8 ft. radius, and in a small room[54]. This formula, however, reduced to sea level at the 45th parallel and to the temperature of freezing[55] becomes $p = 0.00306\ (1 + 0.048\ C)\ v^2$, or closely $p = 0.0031\left(1 + \frac{C}{20}\right) v^2$, in which p is in lbs. per sq. ft., v is in miles per hour, and C is the circumference (or perimeter) of the surface in ft.[56].

51. To any one desirous of studying in detail the many obscure points of fluid resistance, Prof. Abbe calls attention to the valuable work of Saint Venant, Mem. Inst. of France, on Resistance des Fluids, published in 1888, which was received by him too late to be used in his own work.

52. French Railways. In 1887, experiments were made in France[57] with small counterweighted plates suspended laterally from the side of a moving train. The train was run at increasing velocities until the resistance of the air overturned the weighted plates. The velocity of the train at that moment was noted and the ratio of the two computed therefrom. For plates of 0.11 sq. ft. area, at velocities of 44.5 miles per hour, the pressure was thus determined to be in accordance with the formula $p = 0.0054\ v^2$, which is the Newtonian formula with K = 2.0. The measurements were of course rendered somewhat uncertain by the nearness of the sides of the cars. Within the limits of their experiments, no practical effect was obtained from varying the size of the plates.

53. Baker, and Forth Bridge Investigation.—Between 1884 and 1890, during the construction of the Forth Bridge, experiments were made[58] to determine the probable pressure liable to come upon this bridge, as well as the relations between the pressures on large surfaces and the records of the ordinary small plate anemometers. For this purpose a large fixed board gage (or anemometer) 15 × 20 ft., having 300 sq. ft. area, was erected on top of the old castle on the Island of Inchgarvie, near the middle of the bridge, was so placed as to be parallel to the length of the bridge and was further provided with a small disk gage at its center and another small disk gage at one of its upper corners. About 8 ft. on one side of the large gage was also placed another small fixed gage of about 1.5 sq. ft. area, and also a second disk gage of the same size, but differing from the others in that it was free to turn and by means of a vane was kept pointed at the wind. All these vanes were read at about 9 a. m. each day for six years. In the interval from the 11th of December, 1883, to the 25th of January, 1890, the heaviest gales were 14 in number; the records of the first two being rejected because of imperfect arrangement of the apparatus. Of the remaining 12, only 4, those of the 20th of March, 1885, 4th of December, 1885, 17th of November, 1888, and 21st of January, 1890, came squarely against the fixed gages. The records for these days respectively show pressures of 30, 25, 35, and 36 lbs. per sq. ft. on the small revolving plate gage; of 25, 27, 41 and 38 on the small fixed gage; but of only 17, 19, 27 and 15 on the large fixed gage; that is, the large gage showed pressures of 31, 29, 34 and 60% less than on the small fixed gage, and also 43, 24, 23 and 58% less than on the revolving plate gage. The other eight of the severe gales came from directions making about 45°, with the normal to the fixed plates, so that the normal pressures on the fixed plates were probably only about 90% of the actual wind pressures, and should accordingly be increased by about one-ninth or 11.1% in order to give the actually supposed force of the wind itself in the direction of its motion. The actual gage records of those eight storms were as follows: On the 27th and 28th of October, 1884, 31st of March, 1886, 4th of February, 1887, 5th of January, 1888, 2d of November, 1889, 19th and 25th of January, 1890, the pressures were 29, 26, 26, 26, 27, 27, 27, 27 lbs. per sq. ft. on the small revolving plate gage; 23, 29, 31, 41, 16, 34, 28, 24 on the small fixed gage, and only 18, 19, 19, 15, 7, 12, 16, 18 on the large fixed gage; but adding one-ninth (as above stated necessary to correct for the inclination of the wind) the wind pressures become 25.5, 32.2, 34.4, 45.5, 17.8, 37.7, 31.1, 26.7 as deduced from the small fixed gage, and 20.0, 21.1, 21.1, 16.7, 7.8, 13.3, 17.8, 20.0 as deduced from the large fixed gage; that is to say, the pressures on the large gage, if normal, would have been 21, 34, 38, 63, 56, 65, 43, 25% less than on the small fixed gage, if also normal, and also 31, 19, 19, 35, 71, 49, 34, 25% less than on the small revolving plate gage. On all 12 observations together, the large plate thus gave an average of 41% less readings than the small plate gage, and an average of 36% less than the revolving plate gage. On two days, the 31st of March, 1886, and 25th of January, 1890, the large gage was compared further with the two small gages at its own center and upper corner, giving readings of 19 and 18 lbs. per sq. ft. on the large plate, 28.5 and 23.5 on the center gage, and 22 and 22 on its corner; showing on the large plate average pressures of 26% less than at its own center, and 13% less than at its own upper corner. Moreover, as will be seen, during all these six years, the maximum pressure on the large plate was only 27 lbs. per sq. ft. (against 35 on the small revolving plate and 41 on the small fixed plate).

54. In addition to these comparisons on a large scale, Mr. Baker also made small comparative tests with a

(41) See p. 245, same.
(42) See p. 248, same.
(43) See p. 285, same.
(44) See p. 195, same.
(45) See p. 229, same.
(46) See pp. 224 and 227, same.

(47) See p. 207, same.
(48) See p. 224, same.
(49) See p. 224, same.
(50) See pp. 224-5, pp. 229-243, same.
(51) See pp. 289-293, same.
(52) See p. 211, same.
(53) See p. 238, same.
(54) See Hazen, p. 242, Vol. CXXXIV., Am. Journal of Science, 1887.
(55) See p. 236, Abbe; and p. 408, Ferrel.
(56) This formula reduced to the Newtonian form would give K = 1.16 for plates of 1 in. sq., K = 1.35 for plates of 1 ft. sq., K = 3.4 for plates 10 ft. sq., K = 10 for the side of a house of 40 ft. sq., and K over 20 for the side of a building 200 ft. long and 50 ft. high. Evidently this formula is not intended to apply to large surfaces, as under the pressures given by it, no large building would be able to stand even against light breezes.

(57) See Hazen, p. 246, Vol. CXXXIV., Am. Journal of Science, 1887; and R. R. and Engineering Journal, February, 1887.
(58) See p. 221, London Engineering for 28th of February, 1890.

wind blast against small models of open-work trusses and of lattices, and satisfied himself that an allowance of 1.8 of the exposed actual surface of the iron work of the front girder was sufficient to cover the total wind pressures on this and another similar girder in its rear.

55. As this bridge was proportioned to stand 56 lbs. per sq. ft. of actual surface on each girder, the results of the above described six years' subsequent wind measurements seem to show an unnecessarily large margin of safety.

56. On the strength of the above records, Mr. Burr, of Columbia College, New York, feels justified[50] in saying that a 50 lbs. per sq. ft. pressure over the entire length of a 500-ft. long bridge span will probably be as rare as a cyclone.

57. Bidston Observatory Records.—From 1884 to 1888 the records of the Bidston Observatory, near Liverpool, England, show 10 severe storms, whose pressures were measured by a plate pressure anemometer of 2 sq. ft. area, and velocities by the ordinary cup rotary anemometer[50]. These storms and their records arranged in order of their severity are as follows: On the 23d of January, 1884; 20th of May, 1887; 26th of January, 20th of November and 3d of May, 1888; 30th of March, 1886; 29th of October, 1884; 9th of December, 1886; 3d of February and 1st of November, 1887, the pressure plate anemometers registered respectively, 70.2, 65.2, 49.2, 49.0, 44.4, 41.9, 40.6, 40.4, 40.1, and 40.0 lbs. per sq. ft., while the cup velocity anemometer registered 78, 78, 74, 71, 66, 62, 64, 69, 66 and 57 miles per hour. According to the Newtonian formula of $p = K\ 0.0027\ v^2$, the values of K deduced from these records are respectively 4.3, 4.0, 3.4, 3.6, 3.8, 4.1, 3.7, 3.2, 3.4, and 4.6; giving an average of K = 3.8, or $p = 0.01\ v^2$ for the ratio of the registered pressures and velocities. But assuming that the small plate pressure records were 40% in excess of the pressures against large surfaces (according to the Forth Bridge tests as above given), and assuming that the cup velocity anemometer records were the actual velocities of the wind (having already been reduced according to recent investigation), the actual pressures of the wind would reduce to about 42, 39, 30, 30, 27, 25, 24, 24, 24, and 24 lbs. per sq. ft.; the actual velocities of the wind would remain 78, 78, 74, 71, 66, 62, 64, 69, 66 and 57 miles per hour; and the resulting values of K would reduce to 2.6, 2.4, 2.0, 2.2, 2.3, 2.4, 2.2, 1.9, 2.0, and 2.7, averaging K = 2.3 and $p = 0.0061\ v^2$, or $p = \frac{v^2}{164}$ for the actual pressure on large surfaces in terms of the velocities taken from recent records of the usual cup rotary anemometers. As these values of p and K are from 2.4 to 1.4 times as great as those deduced from experiments in which the pressures are far more accurately measured and the velocities are very uniform and measured with exceeding accuracy, it is evident that there is yet much to be investigated either as to actual wind velocities and pressures or the accuracy of the recording apparatus in ordinary use.

58. It is quite possible that the large plate pressure records will in turn have to be reduced 40% more to allow for the effects of inertia under the action of severe gusts. Two successive 40% reductions (64% in all) of the small plate pressure records (making the average steady pressure on a large surface only 36% of that of the maximum unreduced small plate pressure records), combined with a 10% reduction of carefully rated velocity records (making the average steady velocity only 90% of the maximum records of rotary cup anemometers whose coefficient is 2.3, or which are otherwise carefully rated) seems at present the least unreasonable method of reconciling the present apparent differences between the results of experiment with meteorological apparatus and those with other more perfected apparatus. (For the records of the Bidston Observatory from 1868 to 1879, see paragraph 31 under head of Am. Soc. Civil Engineers, papers of 1880.)

59. Fidler.—In 1887, T. C. Fidler, in his book on Bridge Construction[51], devotes one chapter to the subject of wind pressure[52] with special reference to its bearing on bridge construction. This chapter is perhaps the best single short, concise, comprehensive and practical review of the whole subject yet in print. From it are taken the following points, not as well brought out elsewhere above.

60. In bridges of large span the wind stresses become of great importance since they may be as great as those produced by the entire dead and live load. In the Forth Bridge, where the allowance for wind stress was 56 lbs. per sq. ft. over the exposed surfaces of both girders, the maximum stresses due to wind pressure alone were estimated by the engineer as 2.9 times that due to the live load and 1.3 times that due to the dead load.

61. In a bridge whose sides are solid girders, the horizontal wind pressure on the whole bridge will depend greatly on the connection of those girders. If the side girders are connected top and bottom by solid ceilings and floors so as to make the combination act like a cylindrical solid instead of like two thin plates, then the total pressure on the bridge will be less than on one single solid thin girder standing alone; if connected by only a solid floor without roof, then it is possible that the shelter of the floor may equalize its skin-friction with results that the total pressure on the bridge will be only as much as on one solid girder alone; if connected by an open platform, then the total pressure on the bridge will be something between 1.0 and 2.0 times that of a single solid girder standing alone.

62. The wind pressure on the side of a railway car is only about 0.8 that on a similar thin surface if standing alone, and that of a house or monument touching the ground is probably still less; so that in computing wind pressures from the overturning of cars of monuments, we must ordinarily increase the computed pressure by at least 25% in order to get the pressure which would have been exerted on a thin pressure gage surface of the same area. In the same way, it is found that the pressure calculated from the breaking of ordinary window panes in the side of a closed house must be increased by 50% in order to get the corresponding pressure on a thin plate alone or on the ordinary wind pressure gage.

63. When the wind blows upon a grating or lattice girder, the pressure on the grating or girder is somewhere between that of the entire area enclosed by its perimeter and that of the actual front surface of the bars or plates that compose it; and the pressure on a second girder in rear of the first would usually be less than that on the first. Gaudard is quoted as expressing these pressures by the formulae

$$P = p\ S\ (1 - k\frac{s}{S});\quad P_1 = P\ k\frac{s}{S};\quad \text{and } P + P_1 = p\ S\ (1 - (k\frac{s}{S})^2);$$

in which P is the total pressure on the front girder, P_1 is the total pressure on the rear girder, $P + P_1$ is the total pressure on both girders, p is the wind pressure per unit of surface, S is the total area inside the perimeter of the girder, s is the total combined areas of the openings in the girder, and k is a constant of contraction, assumed by Gaudard to vary between k = 0.65 for small orifices and k = 1.0 for large openings. Fidler, however, suggests the need of practical tests of this formula, stating that while some such formula may be true for special girders, it is very probable that the amount of shelter varies somewhat with the shape and arrangement of the lattice bars, and very certain that it varies very greatly with the distance between the girders.

64. In girders of wide open panels and comparatively narrow bars, any particular bar on the front of the windward girder will shelter almost completely another similar bar close to it (as when bars are close in pairs), will also slightly shelter it at from 1 to 2 diameters distance, but will not shelter it at all appreciably at 6 to 10 diameters distance. Mr. Baker, of the Forth Bridge, found that if two similar disks were placed exactly in rear of each other, but at distances apart of 1.0, 2.0, 3.0 and 4.0 diameters, the total pressure on the combination amounted respectively to 1.0, 1.4, 1.6 and 1.8 times the pressure on the front disk alone; and that this total pressure was but little if any increased by the insertion of intermediate disks. Experiments by Thibault, however, show as much as 1.7 pressures at single diameter distances, so that further experiment is needed in this direction.

65. Allowances should be made for the dynamic effect of sudden gusts, especially in high winds, as a gust which lasts as long as the time of oscillation which is thereby given to the bridge may produce the same stress in the bridge as that directly deducible from the extreme pressure given at the same time by a pressure gage anemometer. This stress may, moreover, be much further increased should the interval between gusts happen to be in rhythm with the time of oscillation of the bridge. In consulting the records of wind anemometers, this dynamic effect must be borne in mind, as the records may show 1 to 2 (or even more) times the actual pressures and velocities, according as the wind is steady or very gusty. The general results of practice so far tend to show that in a squally wind the dynamometer or pressure plate gage may record from 40 to 75 lbs. per sq. ft., while the actual pressure upon a thin plate might only be about 37 lbs., that against overturned carriages be only 30 lbs., and that against broken windows only about 25 lbs.

66. In most bridges, the wind pressures are provided against by horizontal wind-girders, lying in the plane of the bridge floor, assisted in some cases by another similar wind-girder overhead. In most cases, these wind-girders are of uniform width, equal to that of the bridge, and are therefore calculated like any other truss or girder with parallel chords and lattice or open-work posts and diagonals. In special cases the wind-girders may be constructed as entirely independent girders, so as to have no work or duty except the resistance of the wind pressures; but whenever, as in most cases, they are combined with the other parts of the bridge, any piece so subjected to both kinds of stress must be proportioned so as to resist the maximum stress that may result from the most unfavorable combinations of wind, dead load of bridge, and live load of moving vehicles.

67. As it is hardly possible for the wind pressure to be always uniform over the entire length of bridge, nor to be blowing with full force on one-half and with no force at all on the other half, it is advisable, especially on long bridges, to consider one-half the wind-pressure on the girders as a dead load uniform over the whole bridge, and the other half of such pressure on the girders, as well as all the pressure on a moving train, as a rolling load.

68. As cars are liable to be blown over with pressures of from 26 to 34 lbs. per sq. ft. pressure, no train is therefore likely to enter a bridge under such wind pressures; still, as one may be caught upon it (as in that of the Tay Bridge), it is advisable to consider such possibility.

69. The Board of Trade Commission (shortly after the Tay Bridge disaster) recommended an allowance of 56 lbs. per sq. ft. on once to twice the actual front surface of the material in one girder, with a factor of safety of 2 against overturning and 4 against rupture; and the Forth Bridge was built in accordance therewith.

70. However, although up to about 1880, the general best practice of English engineers was to provide against wind pressures of from 30 to 40 lbs. per sq. ft., and of American engineers to provide against from 30 to 50 lbs., yet the actual cross sections of the wind bracing of many American bridges show that, even if these pressures were allowed on but one girder alone, the resulting stress would be very high and sometimes approach, if it did not exceed, the elastic limit of the materials of the bridge; while in many English bridges, there has sometimes been no wind bracing at all, and it has at other times been totally insufficient to stand anything like pressures of 30 to 40 lbs.; yet these bridges (and many other structures, such as houses, etc., of far less resistance) have stood for a great many years and have proved conclusively that no such actual pressures as 30 to 50 lbs. per sq. ft. have been experienced in the localities where they have been situated.

71. In conclusion, attention is called to the fact that even after all has been said as to wind pressures, it is really impossible at the present day by any general rule to estimate the wind stresses on a long-span bridge to within from 50% below to 100% above their real value. In such cases, the responsible engineer will generally be disposed to err on the safe side. But as this margin of error may make tens or hundreds of thousands of dollars difference in the cost of the bridge, and as on the one hand extra material, not actually needed, can only serve to unnecessarily burden and therefore weaken the bridge, and on the other hand, a lack of sufficient material will give far more disastrous results, it is to-day more than ever specially desirable that further practical experiments and observations should be made to get facts by which to reduce this present large margin.

72. Dines.—In 1888-9, W. H. Dines, at Hersham, England, made some experiments[53] upon the resistance of plates to moving air, from which he deduced the formula $p = 0.0035\ v^2$, in which p is in lbs. per sq. ft. and v is in miles per hour, this being the Newtonian formula with K = 1.25.

73. Eiffel Tower Records.—In 1889, at the Eiffel Tower in Paris, measurements were made during several months[54] upon the relation between the velocities of wind at the top and bottom of the tower at stations 995 ft. apart vertically, the lower station being taken 69 ft. above the ground so as to be clear of the adjacent buildings. In the design of this tower, the wind pressure was allowed for by assuming a pressure of 61.4 lbs. per sq. ft. over the entire height, or 41.0 lbs. at the base, increasing to 82.0 lbs. at the top, according to which gave the highest resulting total pressure at each joint.

74. The observations of 1889 covered 12 days in June, 28 in July, 31 in August and 30 in September, 101 days in all; during which time the wind averaged 4.9 miles per hour at the bottom and 15.7 miles at the top, while the top velocities exceeded 17 miles for 39% of the whole time, and over 22 miles for 21% of the time. The ratio between the top and bottom velocities did not remain constant, as the velocities at each place varied, but was 5.0 for bottom velocities of about 3 miles, 4.0 for bottom velocities of about 4 miles, 3.0 for bottom velocities of about 5 miles, and 2.0 for bottom velocities of about 7 miles.

75. Marvin.—In 1890, some experiments were made on top of Mt. Washington, N. H., by C. F. Marvin, with surfaces of 4 sq. ft. and 9 sq. ft. area[55], from

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(50) See p. 475, Burr, Stresses on Bridge and Roof Trusses.

(51) See p. 333, London Engineering of 14th March, 1890.

(52) T. Clayton Fidler, Practical Treatise on Bridge Construction, 432 pages; London, 1887.

(53) See pp. 402-418, same.

(54) See p. 333, London Engineering, 14th March, 1890; and p. 63, Langley in Smithsonian Contributions No. 801.

(54) See p. 121, Sci. Am. Supplement for 19th July, 1890.

(55) See Johnson, Modern Framed Structures, p. 33; also Engineering News of 13th December, 1890.

which he deduced the formula $p = 0.004\ v^2$, in which p is in lbs. per sq. ft. and v is in miles per hour. The unit pressures were found practically the same for both large and small surfaces.

76. Crosby & Dashiell.—In 1890, O. T. Crosby, late Lieutenant, Engineer Corps, U. S. Army, and B. F. Dashiell, made a series of experiments[66] with plates of from 1.0 to 2.0 sq. ft. cross section moved with velocities of from 10 to 130 miles per hour (those of 30 miles being numerous) in circles of 5.5 ft. radius in a room about 40 ft. long, 13 to 19 ft. wide and 12 ft. high. The apparatus was belted to and driven by a 90-HP. steam engine, whose speed could be regulated to less than half a revolution. The velocity of the plates was computed in most cases from actual count (electrically or otherwise) of the revolutions of the whirling table. The plates revolved at distances of only from 2.5 to 5.0 ins. above the platform of the whirling table, but at much greater distances from the sides of the room. The pressures were measured by the compression of springs in rear of the plates and continuous automatic records of the same. Great care was taken in first measuring the resistance of the apparatus itself, this resistance being afterwards deducted from that shown by the plates and apparatus together, in order to obtain the net resistance of the plates alone. The marked radial and rotary motion of the air in the room due to the rotation of the apparatus, though not carefully measured, was allowed for by adding 10% to the recorded pressures. On account of the apparent large errors from friction and inertia at low velocities, no accuracy is claimed for velocities of less than 30 miles per hour. The result of these experiments indicated that at high velocities, the resistance to normal pressure of air was much less than called for by the Newtonian formula and that at velocities from 30 to 130 miles per hour and for short solid bodies with flat heads of 1.0 to 2.0 ft. sq. cross-section, the relation of pressure to velocity is expressed by the formula $p = 0.144\ v$ or $p = \frac{v}{7}$, in which p is in lbs. per sq. ft. and v is in miles per hour. These resistances were found to be about 28% less in the case of the addition of a wedge-shaped head whose height was equal to its base, about 30% for a pyramidal head whose height was twice its base, about 45% for a wedge head whose height was twice its base, and about 50% for a parabolic wedge whose height was equal to its base.

77. These results, especially that the pressure varies with the first power of high velocities, being of so surprising a nature, were checked by further experiments with a small flat-headed car of 5.1 sq. ft. cross-section, driven by an electric motor around a track of about 2 miles circumference at a speed of about 50 miles per hour; the pressures being measured in much the same way as before by the use of compressed springs and automatic records. The total registered pressure on the entire 5.1 sq. ft. front surface was less than 40 lbs., that is, less than 8 lbs. per sq. ft.

78. In connection with his report on these experiments, Lieut. Crosby also reviews the work of his predecessors in this line of research. His review, interesting in itself, shows that his own experiments were entered into by him understandingly, and his results are, therefore, entitled to all the more consideration. Attention is called to the almost unanimous opinion of all investigators up to date, that the practical law of pressure velocity variation between any two definite limits of speed must be deduced from actual and carefully made experiments between these same limits, and that the relations deduced from experiments with the lower velocities cannot safely be rigorously applied to higher velocities. As to the effect of the size of plate upon the pressure per unit of surface, Crosby infers the trend of authority towards an increase of this pressure as the surface increases in the case of moving plates; and perhaps the reverse in the case of stationary plates. As to the pressure on inclined plates, he tabulates the results of a dozen formulae obtained by other investigators, and gives as the result of his own experiments a value of $p = \frac{\sin a + \sin^2 a}{2}$ for the horizontal pressure per sq. ft. of plate, and $p = \frac{1 + \sin a}{2}$ for the horizontal pressure per sq. ft. of the vertical base of the plate; both formulae being for plates moved horizontally, a being the angle between the surface of the plate and the direction of the motion. He calls attention further to the fact that as his moving plate was quite close to the stationary platform of his apparatus, his recorded resistances may have been increased (but at any rate not diminished) thereby.

79. In view of the radical differences between his normal pressure results and those of prior investigators, and in view of the evident errors of formulae for low velocities when applied to high ones, he urges the importance of further careful and extended experiments with velocities as high as (or higher than) those used by him.

80. Langley.—In 1888 and 1890, S. P. Langley, of the Smithsonian Institution, made a set of very interesting experiments at the Allegheny (Pa.) Observatory[67] with plates of from 0.25 to 1.00 sq. ft. area, with lengths of from 0.15 to 6.2 times their breadth, moved at velocities of from 10 to 70 miles per hour in circles of 30 ft. radius in the open air, and at distances of at least 8 ft. above the ground, the whirling table being driven by a 10-HP. steam engine under 90 lbs. of steam, steadied by a flywheel making about 120 revolutions per minute; the velocities of the plates being measured by an electric chronograph recording every quarter revolution of the whirling table, and the pressures being recorded automatically by the compression of carefully calibrated springs connected to the plate-holder. Friction wheels were introduced wherever it was desirable to allow motion, so as to reduce the friction as much as possible, and many other methods were adopted to minimize the amount of unnecessary instrumental friction and oscillation. With respect to the pressures on thin plates, moved through air, those experiments give results as follows: For plates held normally to their line of motion[68], and at temperatures of 50° Fahrenheit and barometric pressures of 736 mm., $p = .0036\ v^2$ or $p = \frac{v^2}{280}$, in which p is in lbs. per sq. ft., and v is in miles per hour. If reduced to freezing temperatures and the normal of 760 mm. (as in previously described formulae) this becomes $p = .0039\ v^2$, or $p = \frac{v^2}{260}$; being the Newtonian formula in which $K = 1.44$. This result is deduced from the records of 68 different observations[69], whose velocities were well scattered between 10 and 70 miles per hour, and whose deduced pressures rarely differ by as much as 10% from that of the average as given by the above formula. As to the effect of varying size of plates, the 6-in. sq. plates gave results slightly more than the 8-in. sq. plates, but slightly less than the 12-in. sq. plates; so that the result was not indicative of any special law governing such variation. As to the pressure on the inclined thin moving plates, it was clearly shown that the resultant pressure on the inclined plate is normal to the inclined surface[70], and hence that the effects of skin friction, viscosity, and the like are practically negligible in such experiments; that this normal pressure upon the inclined surface is much greater (even 20 times in the case of angles as small as 5°) than that deducible from Newton's original discussion, and agrees[71] very closely (within 0.02) with that of Duchemin's formula of $\frac{2 \sin a}{1 + \sin^2 a}$, in which a is the angle between the plate and the line of motion; that the center of this resultant and normal pressure is not exerted at the center of the inclined plate, but always a little forward of the same, towards the advanced edge of the plate[72], so that the forward half of the plate always carried more than half this total pressure, the amount of these variations depending on the angle of inclination of the plate (as also shown by Joessel in 1870 and Kummer in 1875-76); that this pressure, being a fluid pressure and increasing rapidly with the velocity, has, in the case of horizontal winds at high velocities under small angles of inclination, a lifting power far greater[73] than it is ordinarily given credit for; and also that inclined rectangular planes whose surfaces are inclined from 0° to 30° to the line of motion[74], may experience much greater or much less pressures than square plates, according respectively as their longer or shorter side is in advance, while those whose surfaces are inclined from 30° to 90° may experience exactly the reverse effects, thus showing that not only the shape, but the orientation of the inclined surfaces is of great importance in determining the resistance offered by them to their own motion, or to that of the fluid in which they are moved. The results of these experiments, both on account of the great radius (30 ft.) of the whirling table, the great care taken to eliminate the difficulties and errors of prior experimenters, and the high velocities actually obtained, must necessarily be given great weight in comparison with those of other like prior experiments, and seem to be sufficient proof of the theory that air pressures on moving plates under velocities up to about 70 miles per hour are (to within at least 10%) proportional to the square of velocity, leaving the question of the discordant results obtained from ordinary wind pressure and velocity gages and the question of the pressure of moving air upon stationary plates to be further investigated, if necessary, by methods in which the motion shall be that of the air and not that of the plate.

18. Mauritius Cyclone.—On the 29th of April, 1892, a cyclone, crossing the Champ de Mars, Port Louis, Mauritius, struck an obelisk of 50 ft. height and 5 ft. sq. cross section (called the Tombeau Malartic), tearing off and throwing down its upper half[75]. The portion thus thrown down was 26 ft. high and 5 ft. 3 ins. square at its surface of rupture, and was built of hard blue basalt facing, backed with rubble bedded in mortar. The appearance of the fracture indicated that the upper portion did not slide off from the lower, but was lifted clear from it. Calculations from the exposed surface and weight of the fallen portion showed that the mere overturning of the upper half of the obelisk would require a force of 142 lbs. per sq. ft. of its exposed surface. The director of the observatory at that place reported the maximum velocities of his records as 112 miles per hour for the greatest hourly record and 123 miles per hour for the greatest velocity for a few seconds. If the velocity be taken at 112 miles per hour, and the pressure at 142 lbs. per sq. ft., the ratio of the two would be expressed by $p = \frac{v^2}{88}$.

82. Langley (as to gusts).—In 1887 and 1893, S. P. Langley, of the Smithsonian Institution, made a series of experiments[76], first at the Allegheny (Pa.) Observatory, and then at the Smithsonian Institution, Washington, D. C., to determine the internal irregularities and variations of ordinary winds. At Allegheny, he used an ordinary rotary Robinson cup anemometer, with metal cups of about 3 ins. diameter, moving in circles of 6.75 ins. radius, recording every 25th revolution, placed on a mast so as to be 53 ft. above the top of the hill and 453 ft. above the adjacent Ohio River valley. The observations at Washington were made with three different sized anemometers, the first being about the same as that used at Allegheny, but recording every fifth revolution; the second being made with paper cups, of only 0.3, the weight of the first one, and recording every revolution, and the third being made of half size and with paper cones, weighing only 0.02 of the first, and recording every half revolution; these anemometers being mounted 153 ft. above the ground (11 ft. above the tower parapet). The third anemometer, whose moment of inertia was thus less than 0.01 of that of the first one, would start and stop almost instantaneously with the wind. These anemometers showed that even in ordinary winds (and more so in high winds) the air moves in a tumultuous mass, the velocity at a single fixed point sometimes jumping almost instantaneously from one extreme to the other. The general characteristics of these variations is well shown by the record of the 6 minutes from 10 to 16 minutes past noon on the 4th of February, 1893, at Washington, when an ordinary high wind of from 20 to 27 miles an hour was blowing. The record of the ordinary anemometer showed a velocity of about 25 miles per hour at the beginning of this interval, dropping to about 20 miles at the end of the first mile, rising to about 27 miles at the end of the second mile and continuing at this rate for some time afterwards. The record of the light anemometer, registering each revolution, shows, however, starting at 23 miles, a rise to 33 miles in 10 seconds, then a fall to 23 miles in 10 seconds, then up to 36 miles in 30 seconds, and so on, passing through 18 notable maxima and as many minima in these six minutes, the average time of each rise or each fall being a little over 10 seconds, and the average change in velocity being about 10 miles an hour. The most rapid change in this interval was a drop from 24 miles down to nothing and a rise back to 22 miles, all in less than 15 seconds. In like manner, the observations of the 16th of July, 1887, with average velocity of 18 miles, showed a rise and fall of 33% each way from the mean, occurring within two minutes of each other; those of the 14th of January, 1893, with 13 miles average velocity, 40% oscillation within 0.5 minute; those of 20th of February, 1893, with 27 miles average velocity, 75% in 0.3 minute, and holding a 60% increase for nearly a whole minute; while during all these observations the average oscillation was about 20% up or down, and occurred once or twice a minute. Under such circumstances, because of their weight and great inertia, the ordinary rotary anemometers, while failing to show the maximum velocities, would record average velocities considerably in excess of the truth; while the ordinary plate anemometers would record instantaneous pressures far in excess of the truth.

83. Kernot.—In 1893, Mr. Kernot, of the Melbourne University, Australia, made a series of experiments[77]

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(66) See pp. 663-4, 689-90 and 715-18, London Engineering, 30th May, 6th June and 13th June, 1890.

(67) Langley, Experiments in Aerodynamics, 115 pages, 10 plates, 1891; published in Smithsonian Contributions No. 801.

(68) See p. 99, same.

(69) See p. 98, same.

(70) See p. 104, same.

(71) See p. 24, same.

(72) See pp. 89 and 114, same.

(73) See pp. 25 and 105, same.

(74) See pp. 61-2, same.

(75) See Engineering Record for 23d July, 1892.

(76) See Langley, Internal Work of the Wind, 1893; published as Smithsonian Contributions No. 884.

(77) For abstract of paper, see p. 176, Vol. XXIX., Engineering Record for 10th of February, 1894.

with a steady jet of air of 12 by 10 ins. cross section, directed upon small models. The blast was furnished by a screw propeller of 28 ins. diameter and 48 ins. pitch, driven by a gas engine, at speeds of from 400 to 800 revolutions per minute. The helical currents of air from this propeller were collected by means of a radial diaphragm and a conical mouthpiece, having its axis tangential to the helical direction of the air, so as to secure a steady jet. In front of this jet was placed the object to be tested, supported on a very delicately arranged carriage running on an accurately levelled surface plate; the force exerted being measured by a delicate spring balance, the accuracy of which had been verified by means of standard weights. A large number of experiments were made with this apparatus. From the small size of the models, and the necessary delicate arrangement of the apparatus, results could not be expected sufficiently accurate to be used in the revision of the general pressure and velocity formulæ; but very interesting comparisons could be made. Comparing various surfaces, exposing to the blast equal areas and assuming the pressure to be 1.00 on a sq. unit of thin plate, normal to the blast, it was found that the pressure was 0.90 on the side of a cube normal to the blast, 0.90 also on the cube turned edgewise, 0.80 on the side of a square pyramid whose axis was normal to the blast, 0.96 on the same pyramid turned edgewise, 0.60 on octagonal prisms, 0.50 on cylinders and cones, 0.36 on spheres, 0.36 one way and 1.15 the other on spherical cups, and 0.80 on lattice work whose openings were 55% of the whole exposed area. The pressure on cylinders and spheres could be increased 20% by bringing near them a plain surface parallel to the wind, the lateral escape of the wind around the cylinder being thereby cut off. In the case of a hollow building turned with open side toward the wind, the pressure to lift the roof and force out the sides was equal to the pressures on the exposed end. The variations of pressure caused by the proximity of other surfaces was very marked; each surface appeared to affect the pressure on other surfaces to a distance in front equal to once, and in rear equal to several times, its own breadth. The pressure on a 6-in. disk was reduced 60% by the presence of a 9-in. disk placed 2 ins. in its rear; and this reduction of pressure diminished as the 9-in. plate was moved back, disappearing only when the rear disk was about 9 ins. (its own diameter) in rear of the 6-in. disk. The pressure on a 7-in. disk was diminished 120% (i. e., it was urged forward against the direction of the wind with 20% pressure) by the interposition of a 9-in. disk placed 4 ins. to its front. A parapet of 0.16 of the height of a roof reduced the pressure on the roof by 33%. A wall connecting the edge of the roof with the ground in its front reduced the pressure on the roof to very much less than it was when the wind could blow freely under the roof. Mr. Kernot concludes his paper by a recommendation that 20 lbs. per sq. ft. be regarded as sufficient allowance for wind pressures in positions of full exposure in Australia whenever the exposed surface measures over 300 sq. ft., and that 30 lbs. be allowed only upon smaller surfaces of exposure; and recommends further that the factors of safety be taken as 2 against over turning and 3 against rupture.

RECENT PRACTICE.

84. Foreign Practice.—The practice of to-day in England is presumably in accord with the recommendation given under the heads of the Tay Bridge commission and London Engineering articles (1880-1) and Fidler (1887); which is, to estimate the maximum wind pressure at each place by the formula $p = 0.01 v^2$, in which v is taken from the rotary cup anemometer records; and in the most exposed places to allow for 56 lbs. per sq. ft. wind pressure over from 1.0 to 2.0 times the effective area of one bridge girder.

85. The practice of to-day in France is presumably in accord with the rules laid down by the text-books of the Corps of Bridges and Highways(79), which estimate the wind velocities of storms at 100 miles per hour, and which allow for pressure of 60 lbs. per sq. ft. over the effective area of one truss of a solid truss bridge, or of 1.5 trusses of an openwork truss bridge.

86. These recent English and French allowances seem more than necessary in long bridges, where the cost of the wind bracing is a question of hundreds of thousands of dollars, especially in view of the fact that so many bridges with so much less wind bracing have stood so well for years, and that one (see Shaler Smith, 1880, par. 28), dimensioned for only 30 lbs. pressure, stood safely even when one of its spans was actually crossed by the very center of a tornado.

87. American Practice.—The American practice as it stands in 1894 may best be gaged by the rules laid down in the last edition of the text-books (79) of Johnson, Bryan and Turneaure, of A. J. Du Bois, and of W. H. Burr.

88. Wind pressures. In these works, the relation of pressures to velocities is variously expressed by the formula(80) $p = 0.0040 v^2$, $p = 0.0054 v^2$, and $p = 0.0100 v^2$, respectively, in which p is in lbs. per sq. ft. and v is in miles per hour; being the Newtonian formula with K = 1.5, 1.9 and 3.7. However, they all agree in the ordinary allowances of 30 lbs. per sq. ft. for wind pressures on large surfaces(81); while increasing this to 45 lbs. (Johnson) or 50 (Du Bois) or 40 (Burr) for small surfaces and unloaded bridges. The ratio of the normal pressure upon inclined surfaces to the normal pressure on normal surfaces is given by both Johnson and Du Bois(82) as sin a to the 1.84 cos a — 1 power (quoted from Unwin, 1869, as ascribed by him to Hutton), in which a is the angle of the surface with the wind; this giving 1.00 for angles of from 90° to 60°, 0.95 for 50°, 0.88 for 45°, 0.83 for 40°, 0.66 for 30°, 0.45 for 20°, 0.24 for 10°, and 0.13 for 5° (these results for angles less than 50° being all considerably smaller than those of Duchemin's and Langley's formulæ).

89. Bridge Spans.—The rules for the application of these wind pressures to the calculation of large railroad bridges are mainly as follows(83): The exposed area of spans is figured: First, of the unloaded bridge, the wind pressure being treated as a dead load; second, of the loaded bridge, the wind pressure on the train being considered as a live load; and then each portion of the wind bracing is dimensioned to stand the maximum strain that may come upon it under either condition of load. The exposed area of a girder is measured by taking the front surface of each part (such as the ordinary upper chords and posts) which stands by itself, 1.5 times the front surfaces of those parts (as ordinary ties) which are in pairs, and 2.0 times the front surface of those parts (as ordinary lower chords) which are composed of several bars, one behind the other(84). The wind pressure on the unloaded bridge is calculated at 30 to 50 lbs. per sq. ft. on the exposed area of the floor system, and of either both open girders or one closed or plate girder(85). The train is treated(86) as a continuous surface of 10 ft. height, with its bottom 2.5 ft. above the rails. The exposed area of the loaded bridge(87) is measured by adding together the exposed surfaces of all the windward girder of the floor system, of the train, and of all the leeward girder (or at least of so much of it as is not closely and completely sheltered by the train). The wind bracing is usually composed of a horizontal truss under the floor, and one between the top chords of all through bridges, or between the bottom chords of all deck bridges, and of vertical sway bracing at every panel point of high through bridges or at the panel points of all deck bridges. The dead load of the wind pressure is assumed ordinarily as divided equally between the upper and lower wind trusses, where both exist; and the live load is assumed ordinarily as all carried by the wind truss of the loaded chord (the lower in a through bridge, the upper in a deck bridge). In ordinary long railroad bridges, these wind loads are ordinarily assumed(88) at 600 lbs. (300 dead, 300 live) per lin. ft. of bridge, of which ¾ (as above explained) goes to the wind truss next the flooring and ¼ to the other wind truss. In calculating the stresses on each wind truss, the loads are assumed as exerted on the windward side. The chords and end posts of the main trusses are not usually stiffened or increased in size on account of the assumed wind stresses, except: first, when such stress, alone or in combination with a temperature strain, may change the strain from tension to compression in a chord built to stand only tension; and second, when the wind stress on any member exceeds 25% of the sum of the maximum stress due to the dead load added to that due to the live load(89).

90. Members subject to alternate tensile and compression stresses are built to resist each, and proportioned so as to stand each stress alone, increased by an amount equal to 80% of the lesser(90). Where the wind acts, the bridge is necessarily bent somewhat to the leeward side, and the tension chord of that side of the bridge must be made strong enough to stand this extra stress. Under the same circumstances, the tension chord of the windward side is compressed, sometimes in excess of the tension due to the dead load, and therefore precautions must be taken to prevent its buckling under such excess of compression. As the wind may blow in either direction, both directions of wind must be considered.

91. The sway bracing which is placed between the vertical posts of the main trusses at each panel point is introduced in order to prevent independent lateral vibration and swaying of the vertical trusses; also to stiffen the long vertical posts, as well as to assist in carrying some of the wind stresses to the leeward girder. In double-track railway bridges, the sway bracing also helps to prevent lateral distortion of the cross section of the bridge under a load on a single track; but the extra stress due to such work is usually comparatively slight. The main stress on the sway bracing comes usually when the wind is blowing on the unloaded bridge, in which case the web members of the lateral system belonging to the chord supporting the floor are only about ⅓ loaded, while the web members of the other lateral system are fully loaded, giving rise naturally to unequal lateral deflections and the transfer of some stress from the weaker system through the sway bracing to the stiffer system. The parts of the sway bracing are therefore usually dimensioned so as to be able to carry 50% of the wind load due to each panel of the bridge(91).

92. On ordinary heavy railway bridges the exposed areas per lin. ft. may be roughly estimated at 10 sq. ft. for the train, 1 sq. ft. for the ends of the ties and sides of the guard rails, 4 sq. ft. for the longitudinal floor girders (or stringers), and 5.0 sq. ft. per lin. ft. for each truss (or girder), or a total of 10 to 14 sq. ft. for the dead wind load on the two trusses and floor, or 2.5 to 3.5 sq. ft. for each chord(92).

93. In ordinary double-track railroad bridges, with vertical sway bracing, the weight of this bracing(93) for both trusses may be roughly estimated at $\left(\frac{6\ N\ l}{170} + \frac{1136}{p}\right)\frac{b}{15}$ in lbs. per lin. ft. of track, in which l is length in ft., N is number of panels, p is panel length in ft., and b is width of bridge in ft.

94. When bridges are built on a curve they must also be stiffened laterally against the centrifugal force of the moving train(94). This extra stress is estimated at 0.0000117 v D P, in which v is the velocity in miles per hour, P is the weight of the train in tons, D is the degree of the curve or the angle subtended at the center by a chord of 100 ft. of track. For a speed of 30 miles per hour, this amounts to approximately 1% of the weight of the train for each degree of curvature; and each additional 10 miles of speed is assumed to add as much more. This centrifugal force is assumed to act at a level of 5 ft. above the rails. This stress is carried by the floor beams to the posts of the outer trusses and thence through the lateral trusses to the rest of the bridge. As one of the lateral systems usually lies close to the flooring, most of the stress comes upon such system, and its amount is usually added to that of the wind stresses and treated as if it were an extra and live wind load on one side of the bridge.

95. Initial Tension.—All the rods of the wind trusses must be further strengthened to cover the initial tension (ordinarily given them by turnbuckles in bringing all pieces to their proper bearings); and this initial tension is usually estimated at 1.0 ton for 1.0 in. diameter round rods, plus 0.25 ton for each additional 0.125 in. of diameter, or 1.125 tons for 1.0 in. square rods, plus 0.281 ton for each additional 0.125 in. of side, or equal allowances for equal areas of other shapes(94).

96. Piers and Towers.—In the calculation of wind stresses on piers or towers the same rules apply, with slight modifications, as follows: The wind pressure on the whole pier(95) is calculated at that of the front surfaces of the train and of all floor systems of the pier, added to twice that of the trussing of the front face of the tower assuming the wind pressure on the pier and train together at 30 lbs.(96) per sq. ft., and on the unloaded pier at 50 lbs.(97) per sq. ft.; and providing against the most unfavorable of the two cases. In figuring the weight of the loaded pier the train weight is to be taken at that of the lightest train that would not be blown over by a 30-lb. pressure wind. The pier must then be given base enough to prevent its overturning and also enough to prevent any tensile stresses in its posts(98).

97. On the open ironwork piers of the average railroad bridge the exposed area of each side truss of the pier is roughly estimated at 4.5 sq. ft.(99) per lin. ft. of height. The inclined and horizontal bracing of piers and trestles is to be made strong enough to resist the stresses of all wind and centrifugal forces, and of the resistances to horizontal sliding on the foundations; while the columns are to be made strong

(79) See p. 799, E. Collignon, Cours de Mechanique, Resistance des Materiaux, 3d Edition, 1885.
(80) Johnson, Bryan and Turneaure, Theory and Practice of Modern Framed Structures, 527 pp., New York, 1893; A. J. Du Bois, Strains on Framed Structures, 540 pp., New York, 9th Ed., 1893; W. H. Burr, Stresses in Bridge and Roof Trusses, 475 pp., New York, 8th Ed., 1893.

(81) See p. 33, Johnson; p. 66, Du Bois; pp. 370 and 475, Burr.
(82) See pp. 33-4, Johnson; pp. 65-405, Du Bois; p. 370, Burr.
(83) See p. 34, Johnson; p. 65, Du Bois.
(84) See pp. 109-118, Johnson; pp. 405-414, Du Bois; pp. 393-394, Burr. (Johnson, in his work, quotes at length the bridge specifications of F. H. Lewis; while Du Bois in like manner quotes those of Theodore Cooper.)
(85) See p. 405, Du Bois.
(86) See p. 109, Johnson; p. 406, Du Bois.
(87) See p. 393, Johnson.
(88) See p. 110, Johnson; p. 405, Du Bois; p. 370, Burr.
(89) See p. 110, Johnson; p. 405, Burr.
(90) See p. 472, Du Bois.

(91) See pp. 414 and 406, Du Bois.
(92) See p. 418, Du Bois.
(93) See pp. 117 and 393, Johnson; p. 407, Du Bois.
(94) See p. 351, Du Bois.
(95) See pp. 391-399, Johnson; pp. 414-423, Du Bois.
(96) See p. 414, Du Bois.
(97) See p. 396, Johnson.
(98) See p. 416, Du Bois.
(99) See p. 415, Du Bois; p. 399, Johnson.

enough to carry the vertical components of the stresses due to wind and centrifugal forces, as well as the loads of the train, track, girders and pier itself.

98. Longitudinal Bracing.—Ordinarily, no allowances are made for any longitudinal wind stresses on the bridge. The piers, however, need and receive longitudinal bracing[99] to resist stresses resulting from a longitudinal force of about 20%, the dead load of the train (or 800 lbs. per lin. ft.), due to a possible sudden application of the train brakes; and this allowance is also expected to cover any longitudinal wind stresses; but usually the columns of the towers are not given any extra cross section or strength to carry these infrequent stresses, since such stresses will probably not occur during high wind or during other maximum loads[101].

99. Where the end of the bridge slides on a bed plate during extension of the bridge under temperature strains, the stress of sliding friction is usually taken at 25% of the dead load on the bed-plate[102], and is added in with the longitudinal strain due to the application of the train brakes; but special arrangements may sometimes have to be made to take special care of such stresses.

100. Dimensioning.—In ordinary wrought iron railroad bridges (in which the wrought iron has an ultimate strength of 50,000 lbs. per sq. in., with a stretch of 12.5 to 18.0%, and an elastic limit of 26,000 lbs.), the stresses[103] allowed per unit of structure are from 5,000 to 6,000 lbs. per sq. in. of net area on tension floor beam hangers and other members liable to irregular and sudden strain; 8,000 lbs. on floor beams, stringers and plate girders; 15,000 lbs. on tension pieces of wind and other lateral bracing; 9,000 to 10,000 lbs. (reduced for length) on compression posts of lateral and other wind bracing; 7,500 to 8,000 lbs. for other live loads, and 15,000 to 16,000 lbs. for dead loads on tension chords; 7,500 to 8,000 lbs. for live load, and 15,000 to 16,000 lbs. for dead loads (reduced for length) on compression chords and posts of the main trusses; 4,000 lbs. for shearing of web plates; and 7,500 lbs. for shearing, 12,000 lbs. for crushing, and 15,000 lbs. for bending, of rivets and pins. The reductions for length, to be deducted from the above limiting stresses in compression pieces, vary from $30 - \frac{l}{r}$ to $40 - \frac{l}{r}$ for ordinary live loads, from $50 - \frac{l}{r}$ to $60 - \frac{l}{r}$ for wind strains, and from $60 - \frac{l}{r}$ to $80 - \frac{l}{r}$ for ordinary dead loads, in which l is the length of the compressed piece in ins. and r is the least radius of gyration of its section in inches. No compression member is allowed to have a length greater than 45 times its least diameter or width. Girders are given depths of from 1-10 to 1-12 their span.

101. Soft steel may ordinarily be considered as from 10 to 15% stronger than wrought iron; and medium steel as from 20 to 22% stronger than wrought iron[104].

102. New Formulae.—Although the above represents fairly the average practice of to-day in the dimensioning of bracing, there is a rapidly increasing tendency[105] amongst bridge engineers towards determining the dimensions of tension and compression members of all trusses, including those of wind bracing, by the use of new formulae, which take into consideration for each piece its ultimate breaking strength (b) under a single applied tensile stress, its limit of elasticity (e) beyond which a single tensile stress may produce a permanent set, its safe limit for simple repeated strains (p) of either tension or compression alone, its safe limit for repeated reversal of strains (v) from tension to compression, or vice versa, and its maximum (m) and minimum (n) strains in case of simple repetitions of compression alone or tension alone, or its maximum (m) of the kind of strain which is the greater and the minimum (n) of the other kind which is the lesser in case of repeated reversals of strains. The repetition limit has been found by experiment to be a little less than the limit of elasticity, and at the same time to vary between ½ and ⅔ of the breaking strength of the metal; and the reversal limit (called vibration resistance by Woehler) has been found in the same way to vary between ½ and ⅔ of the repetition limit. In the case of an ordinary wrought iron, whose ultimate strength, or ordinary breaking limit, is 50,000 lbs. per sq. in., the elastic limit may be about 60%, or 30,000 lbs.; the repetition limit about 52%, or 26,000 lbs.; and the reversal limit about 32%, or 16,000 lbs.

103. Launhardt and Weyrauch Formulae.—From the results of the experiments of Woehler and others (as published in 1870 and following years), Prof. Launhardt has deduced formulae of the form of $s = \frac{1}{c} p \left(1 + \frac{b-p}{p} \cdot \frac{n}{m}\right)$ for repeated stresses of either tension or compression alone; and Prof. Weyrauch has deduced formulae of the form of $s = \frac{1}{c} p \left(1 - \frac{p-v}{p} \cdot \frac{n}{m}\right)$ for repeated stresses of alternate tension and compression; in which s is the safe load, c is a constant of safety, taken usually at about 3.5, and the other quantities are as above described, all values being in the same unit, usually lbs. per sq. in.

104. If $p = b/2$ and $v = p/2$, as in ordinary grades of wrought iron, then these formulae reduce to $s = \frac{1}{c} \cdot \frac{b}{2} \left(1 + \frac{n}{m}\right)$ for repeated stresses of either tension or compression alone, $s = \frac{1}{c} \cdot \frac{b}{2} \left(1 - \frac{1}{2} \cdot \frac{n}{m}\right)$ for repeated stresses of alternate tension and compression, and $s = \frac{1}{c} \cdot b$ for unvarying dead load stresses, $s = \frac{1}{c} \cdot \frac{1}{2} \cdot b$ for repeated stresses of equal intensity, if unreversed, and $s = \frac{1}{c} \cdot \frac{1}{4} \cdot b$ for repeated reversed stresses of equal intensity.

105. If $p = \frac{2}{3} \cdot b$ and $v = \frac{2}{3} \cdot p$, as in some special grades of wrought iron, then these formulae reduce to $s = \frac{1}{c} \cdot \frac{2}{3} \cdot b \left(1 + \frac{1}{2} \cdot \frac{n}{m}\right)$ for simple repetitions, $s = \frac{1}{c} \cdot \frac{2}{3} \cdot b \left(1 - \frac{1}{3} \cdot \frac{n}{m}\right)$ for repeated reversals, and $s = \frac{1}{c} \cdot b$ for unvarying dead-load stresses as before, $s = \frac{1}{c} \cdot \frac{2}{3} \cdot b$ for repeated stresses of equal intensity, if unreversed, $s = \frac{1}{c} \cdot \frac{4}{9} \cdot b$ for repeated reversed stresses of equal intensity.

106. In the case of long struts, the safe load must, of course, be further reduced by the usual formulae applicable to such cases; either Rankine's or Gordon's, or that given above. (See footnote [106].)

107. The use of these new formulae is therefore equivalent to that of the old formulae modified by a variable coefficient of safety such as, in the most disadvantageous combinations of live loads, to allow on ordinary metal only 1/4 and on the best metal only 4/9 of the stress that would be allowed upon it, if the stress were unvariable. Such formulae seem to be far better than those of the older method for the safe and advantageous dimensioning of the different parts of trusses in ordinary work. The Pennsylvania Railroad formulae for bridge trusses may be deduced from the above by making $p = b/2$, $v = p/2$, and $c = 3.5$; which allows no metal, even under quiet dead loads, to receive a stress of over 2/7 of its ultimate strength, and which allows metal under the worst combination of live loads (equal alternating tension and compression) to receive a stress of only 1/14 of its ultimate strength. The most serious objection that can be made to these new formulae of Launhardt and Weyrauch is that they are deduced under the supposition that metal by repeated strain within the elastic limit is fatigued in the same general way as when strained beyond such limit, a supposition that still awaits decided proof.

108. Dynamic Formulae.—Fidler, however, suggests that the results of the Woehler experiments may be thoroughly accounted for by the well-known laws of dynamic action, in accordance with which a load instantaneously applied will produce stresses twice as great as will the same load if quiet and constant, and any instantaneously applied increment of load will cause an increment of stress equal to twice that due to an equal increment of quiet and constant load. In accordance with this point of view (whose justness is very fully proved by him), Fidler has deduced formulae which he calls "dynamic" formulae and which (using the same nomenclature as in the preceding paragraph) give m = the stress produced by m acting quietly and constantly, 2 m = the stress produced by m acting instantaneously, 2 (m − n) = the stress produced by (m − n) acting instantaneously, n + 2 (m − n) = m + (m − n) = the maximum stress resulting from instantaneously increasing the stress from n up to m, and n + (1 + a) (m − n) = m + a (m − n) = the general expression for maximum stress in all cases; a being a factor introduced to allow for dynamic action of the force (m − n), equal to 1 when the application is instantaneous, to some intermediate value between 1 and 0 in case of gradual application of the force, and to 0 only when the force is applied so gradually as to be considered quiet and constant.

109. This "dynamic" formula, arranged for comparison with the Launhardt and Weyrauch formulae, therefore becomes $s = \frac{1}{c} \cdot b \cdot \frac{m}{m + n\ (m \pm n)}$ for all cases of varying stresses, the minus sign of n being used for unreversed and the plus sign for reversed stresses, thus giving $s = \frac{1}{c} \cdot b$ for unvarying dead-load stresses, $s = \frac{1}{c} \cdot b \cdot \frac{1}{2}$ for repeated stresses of equal intensity, if unreversed, and $s = \frac{1}{c} \cdot b \cdot \frac{1}{3}$ for repeated reversed stresses of equal intensity, all of which are in perfect harmony with the results of the Woehler experiments.

110. For ordinary use in bridge construction, the new "dynamic" formula takes the form of $A = \frac{m + a\ (m \pm n)}{\frac{1}{c} \cdot b}$, in which A is the desired area for safe loading of the member under consideration, and the other quantities are as before given; the minus sign of n being used, as before, for unreversed and its plus sign for reversed stresses, and a being taken at 1.0 for floor beams (both stringers and cross beams), floor-beam hangers, web bracing and all other pieces subject to very irregularly and suddenly applied strains, being taken at intermediate values of from 1.0 to 0.5 for main girders of spans of from 20 to 100 ft. length, and at 0.5 for main girders of ordinary spans of more than 100 ft. length. This new "dynamic" formula recommends itself by its thorough rationality, its comparative simplicity, its easy adaptability to the varying conditions of actual practice, and its division of the old single coefficient of safety into two distinct parts, of which one, c, depends merely on conditions of manufacture, inspection, and accident, and the other, a, depends on the more easily foreseen conditions of application of its definite rolling or live loads. It now seems quite probable that this new "dynamic" formula will before many years be used in preference to all the others.

111. Application of New Formulae.—Whenever either the new Launhardt and Weyrauch formulae or the new Fidler "dynamic" formulae are carefully applied, it would, however, seem safe to diminish the coefficient of safety from 3.5 to nearly 2.0, so as to utilize the strength of the metal up to nearly its elastic limit; in the case of unchangeable loads, taking care, of course, to see that the maximum allowed load, b/c, never exceeds the minimum elastic limit, e, of such metal as might be expected to actually get into the finished structure, due allowance being made for the ordinary unevenness of manufactured products, the ordinary differences between the results of tests upon small pieces and those upon full-sized members, and the ordinary failures of attempted careful inspection.

112. Wind trusses are, of course, subject to the same variations of temperature as the rest of the bridge, and must be arranged with due regard to such changes. The usual allowance for elongation of iron is 1.0 in. per 100 ft. under 150° of temperature change[107].

113. In analyzing the wind stresses in the laterals, it is well to consider the various wind loads as being transmitted through intermediate parts to the points of final support by such routes as require the least internal work, that is, routes such that the internal work done in producing strain will be minimum[108]. In some cases the weakness or accidental loosening of some pieces of the main or lateral girders may cause the stresses to be transmitted by unexpected routes, and to throw unusual and excessive strains on other parts; and such opportunities must be considered and provided against, if possible.

INFERENCES TO BE DRAWN FROM PAST EXPERIENCE.

114. The above review of past experiment and observation brings out prominently several features specially worthy of note.

115. The wind is now known to be far more powerful, and also far more variable, than it was credited with being in the early days of bridge building and of other engineering construction; and the cost of safely protecting against it is so great that its exact power and variation are of far more importance now to engineers than ever before.

116. The discordant results so far obtained from the cup rotary velocity anemometers, and even the ordinary small plate pressure anemometers, show that more accurate instruments are necessary before their records can be much utilized in the accurate determination of actual wind velocities and wind pressures. At present, their records must be reduced by from 10 to 64% before the results of the velocity and pressure anemometers will be in accord with those of other more accurate apparatus.

117. The normal pressure of the wind on the ends of cylinders of somewhere about three diameters length is unanimously considered less than on either longer cylinders, or on shorter cylinders, or on thin plates of the same head surface. The increased pressure thus acknowledged on short cylinders and thin plates is generally considered to be due to the partial vacuum which is formed by the rush of the wind away from behind the short cylinder or plate; and therefore will diminish with any convexity or pointing of the front head that reduces the scattering of the striking wind, or with any convexity or pointing of the rear surface that will fill up the place otherwise occupied by the partial vacuum, or with any arrangement (like that of numerous small holes all over the front plate) that will allow a little air to go through the plate in quantity sufficient to reduce the partial vacuum. This partial vacuum must also be dependent to some extent upon the shape of the perimeter of the plate, as well as the ratio of the perimeter to the area of the plate; but the amount of this effect is evidently small, or its general effect, at least, would have long ago been settled beyond question. Combining the results of experiment with the ideas of theory, it would seem probable that for each different velocity of the wind there is some ratio of the perimeter to area of plate, at which the partial vacuum per unit of surface is a maximum; so that for a given velocity of wind, the pressure per unit of area will be least for both the largest and smallest surfaces and greatest for some intermediate area.

118. In only one case (that of Crosby, 1890, par. 76) has experiment indicated results departing markedly from the Newtonian law that the normal pressure of the wind is directly proportional to the square of the velocity; and, considering that this result is not confirmed by other experiments (especially those of Langley, 1890, par. 80) with more perfected apparatus at very nearly the same high velocities, it would appear that we must continue to admit the Newtonian law of variation with the square of the velocity, at least for the present, and until it be disproved by the concordant results of many experimenters. At the same time, it is evident that any future change in the old formula is to be towards a reduction of the pressure and not towards its increase.

119. The difference between the results of moving air on still plates and of moving plates against still air, which should be nothing, according to theory, but which was in the first place very considerable, now seems to be rapidly diminishing as experimental apparatus is perfected, and as the errors of such apparatus become better known; so that it is to-day quite probable that this difference will soon be proved so small as to be practically nothing.

120. The extension of wind pressure formulae to other conditions markedly different from those under which these formulae were deduced, is now pretty well admitted to be unsafe; and consequently the real pressures of wind at high velocities is still a matter of considerable doubt, even upon small surfaces, and still more upon very large surfaces. The best that can be done under such circumstances is to temporarily accept the best established results of the past, checking them as far as possible with outside collateral evidence, and to stand by these results while endeavoring to secure others more satisfactorily proven. What is now needed is observation of actual wind pressures at high velocities on large surfaces, such as actual large houses, sheds, or bridges, with measurements of the actual pressure, or deflection, or oscillation thereby produced; and comparison of these results with measurements of the actual wind velocities obtained by some method more certain than that of the ordinary instruments of to-day.

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[99] See p. 404, Johnson.
[101] See p. 404, Johnson.
[102] See p. 397, Johnson.
[103] See p. 395, Burr; pp. 342 and 471, Du Bois.
[104] See p. 488, Johnson.
[105] See pp. 242-245, 322, 488, Johnson; pp. 332-340, Du Bois; pp. 238-259, Fidler.
[107] See p. 469, Du Bois.
[108] See p. 196, Johnson.

121. The component and resultant pressures upon circular and square inclined surfaces seem already known well enough for all practical purposes (see Duchemin, par. 14; Langley, par. 80); but the diminution of this pressure per unit of area due to the increased length of such surfaces in the direction of the wind still needs much further investigation. About all that is as yet definitely known as to this diminution is that under small angles (less than 30°) of inclination of the plate to the wind, the forward portion of the plate so diverts the wind that the rear portion of the plate does not receive as much pressure, nor offer as much resistance as if it stood alone; while under high angles of inclination, the effect is sometimes apparently reversed. (See Langley, par 80.)

122. When the wind is so cornered that its free escape is impossible, as when it blows into the open side of an otherwise closed house or shed or sphere, then the mass of air thus cornered naturally acts as does every fluid under such circumstances, and its pressure is practically equalized in all directions, and is directed normally to all its confining surfaces. Hence, under such circumstances, it is able in many cases to lift roofs and blow out sides of buildings that are parallel, or even somewhat inclined toward, the general direction of the wind, and in this way to exhibit a force which at first thought appears far in excess of that actually exerted.

123. The pressures upon and resistances of spheres, cylinders, cones, pyramids, cups, etc., are not yet as well determined as desirable, the results of various experiments differing sometimes by 50% of the corresponding normal pressure upon flat surfaces of the same area. In many cases, however, this difference is due to want of clearness in the statements of the experimenters, some of whom report the total normal pressure upon the surface itself, while others report only such component of the pressure as is parallel to the direction of the wind, and which therefore represents the resistance of the surface to the wind's motion. In such cases, it is usually well not to adopt extreme reported values; at least, not until the accuracy of their report has been further checked by careful examination of the original records or by comparison with those of other experiments.

124. The extent of shelter given by one body to another adjacent body at its side, or in its rear, as well as the increased pressure that can be thrown upon one body by the near presence of another body, is something as to which the results of the past experiments show wide differences. In both cases, not only the form, but also the roughness of the two bodies should be considered as materially affecting the results. Still, such results as are already attained are yet of considerable value though much further careful investigation is desirable.

APPLICATION TO BRIDGES AND OTHER ENGINEERING STRUCTURES.

125. In reviewing the above experiments with respect to their application to building construction, and weighing the value of each observer's results, according to the circumstances of their method and records, it would seem that the following are safe deductions.

126. Meteorological Records.—As to meteorological records, all maximum wind velocity records of the past derived from the use of the ordinary cup rotary anemometer whose constant of reduction is 3.0 (almost all those prior to 1873, most of those prior to 1885, and even many since), should be reduced at least 20% for 30-mile velocities, and perhaps a little more for higher velocities, to correct for the now known past error in the constants of the apparatus (see Ferrel, par. 42, and Abbe, par. 45); and even after such correction, all these records may have to be still further reduced 10% on account of the unevenness of ordinary and high winds (see Langley, par. 82, and Forth Bridge experiments, par. 53) to get the average wind. But, on the other hand, it is to be remembered that all high-wind velocities (see Langley, 1893, experiments, par. 82) may be subject to repeated oscillations of from 30 to 40% each way from the average at half-minute intervals for several minutes, and sometimes even to an increase of 60% for nearly a whole minute; so that it is not unreasonable to assume the velocities of occasional gusts to be as high as those given by the unreduced records of the ordinary cup rotary anemometer (estimating the wind velocity as 3.0 times that of the cups), and to assume the steady wind velocity during the same time as not over 70% of that given by the same records. Again, all maximum small (say 1.5 sq. ft. area) plate pressure anemometer records (see Forth Bridge experiments) should be reduced at least from 36 to 40%, in order to give the corresponding maximum pressures on large surfaces of 300 sq. ft. area, and about 40% more to allow for the effects of gusts or something else; so that on bridges and houses it is not unreasonable to assume the actual maximum wind pressure of gusts as not over 60% of that registered by the ordinary small plate pressure gage anemometers, and to assume the actual steady wind pressure during the same time as not over 36% of that given by the same records.

127. Ratio of Velocity to Normal Pressure.—As to the direct relation of wind velocity to the corresponding wind pressure upon thin plates normal to the wind, it seems reasonable to assume this as given, for freezing temperatures, by the formula (see Langley, 1890, experiments) $p = 0.0039\ v^2 = \frac{v^2}{260}$ (for the Newtonian formula with K = 1.44); in which p is in lbs. per sq. ft. and v is in miles per hour. For cold winter storms this would become $p = 0.0043\ v^2 = \frac{v^2}{233}$, giving resulting pressures as follows: 4 lbs. pressure for 30 miles velocity, 7 lbs. for 40 miles, 11 lbs. for 50 miles, 15.5 lbs. for 60 miles, 21 lbs. for 70 miles, 27.5 lbs. for 80 miles, 35 lbs. for 90 miles, 43 lbs. for 100 miles, 52 lbs. for 110 miles, 62 lbs. for 120 miles, 73 lbs. for 130 miles, 84 lbs. for 140 miles, and 97 lbs. for 150 miles. (While some experiments show very decidedly that the pressures are no greater than the above, yet, in view of the experiments made by Langely at nearly as high velocities as the others, and under more favorable conditions as to the whirling table, it does not seem wise to adopt the lesser pressures until confirmed by further experiment.)

128. Inclination of Surfaces.—As to pressures on thin inclined surfaces, in terms of the pressure of the same wind velocities on thin surfaces normal thereto, these pressures seem best expressed by the formulae $H = \frac{2 \sin^2 a}{1 + \sin^2 a}$, $L = \frac{2 \sin a \cos a}{1 + \sin^2 a}$, and $N = \frac{2 \sin a}{1 + \sin^2 a}$; in which H is the component parallel to the wind, L the lifting, depressing or side-moving component perpendicular to the wind, and N is the normal pressure on the inclined surface (see Duchemin, par. 14, and Langley, par. 80). These values give H = 1.00, L = 0.00, N = 1.00 for a = 90°; H = 0.94, L = 0.32, N = 1.00 for a = 70°; H = 0.86, L = 0.43, N = 0.99 for a = 60°, and H = 0.67, L = 0.67, N = 0.94 for a = 45°. (For values at intermediate and other angles, see under previous heading of Ency. Britannica, 1880.)

129. As to the pressures parallel to the wind upon solids and curved surfaces, in terms of the pressure of the same wind upon thin surfaces normal to the wind, these pressures seem best expressed as follows: 90% on cubes turned either square or edgewise, 80% on the side of octagonal prisms, 70% on the ends of cylinders of 3 diameters (or more) length, 60% on the convex side of cylinders, and 40% on the convex side of spheres and deep cups (the pressures on convex surfaces being subject to as much as a 1/5 increase in case of their close proximity to any single plane surface which might prevent the easy flow of the wind around the cylinder); 115 to 130% on the concave side of cylinders, channels and flat cups, and 130 to 170% on the concave side of spheres and deep cups.

130. Lattices and Gratings.—As to the effective surface of resistance of lattice work and gratings, it is to be remembered that the first result of scattering a great number of very small holes over the surface of a large thin plate is to allow the wind to go through the plate in sufficient quantity to reduce the partial vacuum otherwise existing on the back of the plate, and thus to immediately reduce somewhat its total resistance, so that this reduced resistance will probably not be much greater than that of a cylinder of 3 diameters length; after which the enlargement of the holes tends merely to change the condition from that of a single large isolated plate to that of a large number of individual small plates touching on two sides only. Moreover, as long as each opening is of small diameter and the total front area of the openings is much less than the total front area of the solid parts, the wind passing through each opening is in the condition of a contracted vein of fluid, and the effective area of resistance to its flow is much greater than the total front area of the solid parts of the lattice. On the other hand, when each opening is of large diameter, and the total front area of the openings is very much greater than that of the solid parts, the contraction becomes comparatively very slight, and the effective area of resistance to its flow approaches very nearly that of the exact total front area of the solid parts alone. From this point of view, and in fair accordance with the theorem of Gaudard (see Fidler, par. 63) and the experiments of Kernot (see Kernot, par. 83), and in default of more accurate knowledge, it would seem reasonable to assume the effective area of a half-open or very open lattice to be at least equal to the front area of its solid portions, increased by a percentage equal to the ratio of the frontage of the solid portion to the frontage of the entire lattice (openings and solid portions together), that is to say, increased by 1% if the frontage of the solid parts were only 1% of that of the whole lattice, by 5% if the frontage of the solid parts were 5% of that of the whole lattice, and so on, until, when the frontage of the solid parts equals the frontage of the openings the total effective area of resistance of the lattice would be 150% of the frontage of the solid parts, or 75% of the frontage of the entire lattice; after which, as the area of the openings diminished, and as long as the openings were large enough to prevent the formation of a partial vacuum in rear of the lattice, the effective area of resistance of the lattice would remain practically constant, and neither much more nor much less than 75% of its total front area. In case that the ratio of openings to solid parts in a lattice is not tolerably uniform over all the different portions of the lattice, then, for purposes of exact computation of its effective area of resistance against wind pressure, the lattice should be divided up into sections such that the above ratio shall be tolerably constant throughout each separate section, and each section should then be computed separately, after which the results may be combined, as may be judged best. While the above rule is thought to be as accurate as present data will justify, further experiment in this direction seems very desirable.

131. Proximity of other surfaces. As to the effective shelter of one surface by another, or the increased pressure thrown upon one surface by the proximity and position of another, their amount must depend greatly upon the shape, form, smoothness and position of each surface; so that only the most general rules are practicable, and these must be modified according to the local circumstances in each particular case. The following rules seem to go fully as far as is authorized by present knowledge, and are given more as suggestions than as actually proven facts.

132. A flat plate may have its own effective area of resistance to the wind considerably diminished by the presence of another larger parallel flat plate directly in its rear, so long as the distance between the two plates is not greater than once the least width of the rear and larger plate, this diminution amounting in exceptional cases to as much as 66% of the normal resistance of the front plate or 30% of that of the rear plate; but in such case the resistance of the rear plate is also diminished, so that the total resistance of the two plates is not much, if any, greater than that of the rear and larger plate if standing alone. As the distance between the plates is further increased, the resistance of each plate increases, until, when the distance between the two plates becomes from 3 to 6 times the least width of the front plate, then the resistance of the two plates together becomes practically what it would have been if each of the two plates had stood entirely alone. On the other hand, a flat plate may have its own effective area of resistance to the wind slightly increased by the presence of another smaller parallel flat plate in its rear, so long as the distance between the two plates is not greater than once the least width of the front and larger plate, this increase amounting in exceptional cases to perhaps as much as 20% of the normal resistance of the rear plate, or 12% of that of the front plate; but in such case the resistance of the rear plate is reversed so that the total resistance of the two plates is not much, if any, greater than that of the front and larger plate, if standing alone. As the distance between the plates is further increased, the resistance of each plate increases, until, when the distance between the two plates becomes from 3 to 6 times the least width of the front plate, then the resistance of the two plates together becomes practically what it would have been if each of the two plates had stood entirely alone. If the two plates be connected together by web plates at their center or side, so as to form an I-beam, channel beam, or hollow beam, the web plates being in each case solid surfaces parallel to the wind, the total resistance of the combination will remain practically unchanged in the case of the I-beam, will be reduced to about that of the larger plate alone in the case of the hollow beam, and will be about half as much reduced in the case of the channel beam. The above rules apply, of course, only to the case of winds normal to the front surfaces of two plates whose centers are in a line with the motion of wind. Cylindrical and spherical plates may shelter each other in similar manner, but to a very much less extent; but it does not seem probable that either the front or rear shelter of convex smooth semi-cylindrical plates will extend to more than one-half the distance nor more than one-half the amount of that produced by flat plates. With convex smooth semi-spherical plates the shelter will probably be less than one-third that of flat plates.

133. Plane surfaces parallel to the wind, placed at the sides of either flat plates or convex smooth cylindrical plates, may greatly diminish or increase the resistance of the latter, according as they assist or obstruct the flow of the wind around the edge of the plates. If put in front or in rear of a plate, and opposite its center line, the effect will be practically nothing; if put on the side of a flat plate and in its front, the resistance of the plate may be slightly increased, and if in its rear, the resistance may be slightly diminished; if put on the sides of a convex cylindrical plate and in its front, the resistance may be increased up to that of a flat plate under similar circumstances, but if in its rear, the resistance may be slightly diminished over what it was before. Channel bars and concave semi-cylindrical bars will usually offer at least as much resistance as flat bars of the same front, and perhaps more.

134. Plane surfaces normal to the wind, such as fences or parapets, may also, by their proximity to other surfaces also normal to the wind, either add to or reduce the resistance of the latter surfaces, according as they deflect the wind away from the latter surface or as they obstruct its passage around the latter surfaces. In such cases, however, the combination of the two surfaces acts usually as a single inclined rough surface of considerable depth, and should be treated accordingly.

135. The advanced portions of large surfaces nearly parallel to the wind, and long in its direction, often serve to a considerable extent as a shelter to the retired portions, in which case the advanced portions may receive more than their average share of the entire pressure, and the retired portions very much less, so much so that the total pressure against such a surface which is long in the direction of the wind, may be much less per unit of surface than if the surface were wider and less deep; in other words, may act towards the wind much the same as a convex cylindrical surface, so that its total resistance will be less than that of a normal plane surface of the same frontage to the wind. On the other hand, if such surface be nearly normal to the wind it may act much the same as a concave cylindrical surface, so that its total resistance may be a little greater than that of a normal plane surface of the same frontage to the wind. If, however, the plane surface is long across the wind and short in the direction of the wind, the preceding results may be reversed so as when nearly normal to the wind to act like a convex cylinder, and when nearly parallel to the wind to act like a concave cylinder.

136. Gratings and lattices afford shelter to objects in their rear in much the same way as do solid plates, though to a less extent, largely dependent upon their greater or less solidity. The sheltered object is exposed, firstly, over its entire surface to a reduced wind pressure from the wind that comes through the openings of the grating, and, secondly, near its edges (and sometimes nearly everywhere) to a nearly full wind pressure from the wind that swings around the outer edges of the grating; this first pressure being at least equal to such a percentage of that on the grating as represents the ratio of the effective area of the openings to the full area of the grating; and the second pressure being at least equal to that which would exist if the grating were replaced by a solid plate. Consequently, in default of more accurate knowledge, the rear surface (whether solid or open) may reasonably be considered as sheltered by the front grating only to the same extent as if this grating were replaced by a smaller solid plate whose frontage was equal to the effective front area of the solid parts of the grating. Where the grating is not uniform in its openings, it should be treated as composed of several smaller gratings, each of which is practically uniform as to its openings.

WIND BRACING OF BRIDGES.

137. Diagonal Wind.—From the above rules it is fairly easy to deduce the approximate wind pressures upon the different parts of a bridge or other engineering structure by taking up each part in detail. In this application, however, it is well to bear in mind the modifications due to diagonal directions of the wind, that is, to those not exactly horizontal and not exactly normal to the bridge axis. It is hardly necessary in modern well stiffened ordinary and long bridges to consider any unlifting wind pressures on the bridge, for general observation testifies to these being of small amount, except in peculiar gorge-like localities or during cyclones or tornadoes. Even in such cases, all that is apparently necessary to the safety of the bridge is to so arrange the flooring that it may be torn up from the floor girders by the wind before the upward lifting wind strain becomes great enough to throw serious strain upon the main bridge girders or trusses. In the earlier built suspension bridges, which were very lightly built, whose suspension cables were not cradled, and which were not stiffened by diagonal stays, the roadway was so easily disturbed from its normal position by slight movements of rolling loads that it was in a state of constant undulation when subjected to even light traffic loads or moderate winds.

Under such circumstances, winds slightly inclined upward from the horizontal could easily send undulations across the bridge and back, and put successive portions of the roadbed in positions inclined to the horizontal enough to allow the wind pressure to lift the roadbed on its windward side and to thus throw greatly increased pressure upon the leeward main cables. This might even happen in case where the main cables were cradled, provided the diagonal stays and stiffening trusses were omitted. But in the modern suspension bridge, using both strong stiffening trusses and strong diagonal stays, no such action need be feared. Downward pressing winds are of still less frequent occurrence and still less force, and therefore need not be considered at all. The greatest wind pressure upon the ordinary bridge will therefore come from horizontal winds, and the greatest strain upon the bridge will be naturally from such as are either normal to the axis of the bridge or nearly so. However, as the wind may be inclined 20° either way from the normal before the normal pressure on the surface diminishes perceptibly, 45° before it diminishes as much as 6%, and 60° before 20%, a diagonal wind, by blowing in behind the front surfaces of vertical and diagonal bracing of all vertical trusses, and by thus reaching all their rear and otherwise protected parts, may throw on the bridge a much greater strain than that due to a normal wind. Therefore, if the strain on the bridge be computed from that of a normal wind, the effective area of all vertical trusses must include at least all surfaces that may be reached by diagonal winds of about 45° angle. This of itself will therefore usually prevent the necessity of considering the question of any possible shelter afforded to each other by paired tie rods or other verticals or diagonals in the vertical trusses.

138. Gusts.—As to the inequalities of the winds, that is to say, gusts, and the sudden pressures thereby brought upon the bridge, it seems reasonable to assume that such gusts will not extend at one time over more than 600 to 1,000 ft. length of any bridge, and that such pressure should be treated like any other live load. However, it should be borne in mind that the maximum pressure of gusts during storms of maximum intensity will occur so rarely, and the strain of the metal will therefore be so slight, that in such cases it is reasonable to allow the stress to reach very nearly the elastic limit of such metal. Moreover, it is necessary to bear in mind the fact that before any gust can act upon the wind bracing of a bridge, it it must take the time and use up the energy necessary to overcome the great inertia of the bridge, this inertia, moreover, increasing very rapidly with the length of the bridge span.

139. Wind Pressure.—Consequently, in long bridges, where periodic oscillation of the bridge has been duly provided against, it would seem that wind pressures would be amply provided for by allowing for, first, a dead-load wind pressure equal to the average steady pressure of high winds over the entire effective area of the bridge, increased by a live-load wind pressure equal to the added effect of 30% added wind velocity (or 70% added wind pressure) over from 600 to 1,000 ft. length of the bridge; and that the value of the wind velocities may be taken at 70 or 90% (according as the anemometer constant is 3.0 or 2.3) of the maximum of the ordinary cup rotary anemometer records of the neighborhood, converted into wind pressure by the use of the formula $p = \frac{v^2}{233} = 0.0043\ v^2$; or the value of the wind pressures of gusts on the large bridge surfaces may be taken at 60%, and the average steady wind on the bridge at 36%, of the maximum of the small plate pressure anemometer records of the neighborhood. Acting upon this basis and the records of 1868 to 1888 of the Bidston Observatory (see pars. 31 and 57), long bridges near that observatory should be prepared to resist the theoretical pressure due to steady winds (computed at 0.9 of the velocity anemometer records) of as much as 83 miles per hour once in 16 years, of 83 to 64 miles perhaps once per year, of 64 to 54 miles perhaps twice in one year, and of less than 54 miles at shorter intervals; or to resist steady pressures (computed at 0.36 of the small-plate pressure anemometer records) of from 33 to 29 lbs. per sq. ft. twice in 16 years, of from 29 to 18 lbs. perhaps once per year, of from 18 to 15 lbs. perhaps twice in one year, and of less than 15 lbs. at shorter intervals; or to resist steady pressures (as deduced from velocity anemometer records and the formula $p = \frac{v^2}{233}$) of as much as 30 lbs. once in 16 years, of 30 to 18 lbs. perhaps once per year, of from 18 to 13 lbs. perhaps twice in one year, and of less than 13 lbs. at shorter intervals; so as to make necessary an allowance of at least 30 lbs. per sq. ft. steady wind pressure over the whole bridge front, and 50 lbs. per sq. ft. gusty-wind pressure over from 600 to 1,000 ft. length. These same limits appear large enough for all ordinary localities in the United States, except in those regions where occasional tornadoes are to be naturally expected and specially provided for.

140. Example.—The computation of wind stresses and bracing upon a long single-track railroad bridge, adapted to the heaviest trains, and having panels of 25 ft. length and 28 ft. depth, and spans of 150 ft. length, would therefore proceed about as follows:

141. Wind Area.—The effective wind area of the roadbed (including the guard rails, ends of the crossties, and track girders) may be obtained by treating the fronts of tie ends as forming a continuous grating with a 75% coefficient, the front guard rails as short solids with a 90% coefficient, the front track girders as H-beams or short solids with a 90% coefficient, considering the length of the ties as of neutral effect, considering the rear guard rails as unsheltered, and considering the rear-track girders as adding about 10% to the area of the front girder; so that the total effective resistance of the roadbed per foot length of bridge may as a rule be taken at about 2.0 sq. ft. for the two guard rails and the ties, and about 5.0 sq. ft. for the two track girders, or about 7 sq. ft. in all.

142. The effective wind area of the main girders or trusses of the bridge may be obtained by treating each of its round vertical or diagonal tie rods as a cylinder with a 60% coefficient (none of them considered as receiving or giving any shelter to the other), each of its vertical or diagonal tie bars as a flat plate with a 100% coefficient (none of them considered as receiving or giving any shelter to the other), each horizontal bar or plate (at eight or more breadths distance in front of or behind another) and each group of horizontal tie bars or plates (one behind the other and within two breadths distance of the broadest plate) as a single plate of the breadth of the broadest with a 100% coefficient, each group of horizontal tie bars or tie plates (one behind the other, and within about four breadths distance of the broadest plate) as a single plate of the breadth of the broadest and with a 150% coefficient, square solid-sided hollow beams as short solids with a 90% coefficient, I-beams and square lattice-sided hollow beams when horizontal as a single flat plate with a 100% coefficient, the same I and lattice beams when vertical or diagonal and with solid sides and open front as a single flat plate with a 100% coefficient, the same I and lattice beams when vertical or diagonal and with solid front and open sides, as two flat plates of sizes equal to their front and rear, each with a 75% coefficient, other open-built beams and octagonal beams as flat plates of the size of the greatest cross section parallel to the track with an 80% coefficient, rough-surfaced cylinders as octagonal beams, smooth-surfaced cylinders and wire ropes and wire-wrapped cables as cylinders with a 60% coefficient, horizontal cylinders as completely sheltering other similar cylinders touching them in their rear and as giving 50% shelter to those at 2 diameters distance and nothing at 4 diameters distance, vertical and diagonal cylinders and octagonal posts as giving no shelter to others in their rear, and the rear main girders or trusses (if lattice work or low solid work) as receiving no shelter from front girders or trusses, but both front and rear trusses being considered as sheltered by so much of the track girders (or stringers) as may be directly in front or rear of their actual surfaces; so that the total effective area of resistance of the main girders may be assumed per foot-length of bridge at about 0.8 sq. ft. for each tension chord, about 1.4 sq. ft. for each compression chord, about 1.0 sq. ft. for both diagonals (after 1-6 reduction for shelter by track girders), about 1.5 sq. ft. for each post (after 1-6 reduction for shelter by track girders), or about 4.5 sq. ft. for each girder, or about 9.0 sq. ft. for both girders.

143. The effective wind area of the two trusses of the horizontal bracing of heavy bridges (so far as not already provided for above) may be taken at that of the diagonals of a single truss, one truss being usually entirely sheltered by the compression chords of the main girders, the other truss, however, being where its posts are sheltered but its diagonals unsheltered; and these diagonals may be treated as short solids with a 90% coefficient; so that the total effective area of the horizontal bracing per foot-length of bridge may be assumed at about 0.2 sq. ft.

144. The effective wind area (due to diagonal wind pressure) of the vertical sway bracing may be taken at that of the diagonals alone, the other pieces either being sheltered or already provided for above; and these diagonals may be treated as cylinders with a 70% coefficient, and as not sheltering each other; so that the total effective area of the sway bracing per foot-length of bridge may be assumed at not over 0.05 sq. ft.

145. For a heavy single-track railway bridge, the total effective area of wind resistance may therefore amount to 7.0 + 9.0 + 0.2 + 0.05 = 16.25 sq. ft. per foot-length of bridge.

146. For double-track bridges, the effective wind area of the roadbed will be increased about 40% by the presence of the added guard rails and track girders, and the effective area of the other parts of the bridge will be increased about the same percentage by the added size of each piece; so that unless specially computed (as, however, should be done in each case in the final revision of plans) the effective area of the double-track structure may be taken approximately as 40% greater than that of a single-track bridge, or as about 23 sq. ft. per foot-length.

147. The effective wind area of the piers or towers may be determined in the same general way as that of the spans, being equal to that of its front truss, its rear truss, the front surface of its various platforms, and the front surface of the diagonals of its sway bracing, so as to amount per foot-height to fully 2.5 sq. ft. per corner, or 5.0 sq. ft. per front or rear side, or 10.0 sq. ft. per foot-height for the entire pier of a single-track bridge or 15.0 sq. ft. per foot-height for the entire pier of a double-track bridge. In calculating the stability of a pier against wind, it is to be remembered that the piers are held down upon their foundations by not only their own weight, but also by that of their share of the bridge and its load, and that they are pressed laterally by not only their own wind load, but also by that of their share of the bridge and its load.

148. The effective wind area of trains may be determined by regarding the train as 10 ft. high, with its bottom 2.5 ft. above the rails, and treating it as a short solid with a 90% coefficient, and considering it as sheltering its own height of the verticals and diagonals of the two trusses, and all trains in its rear; so that the added wind area due to the train will be only about 7 to 8 ft. per foot-length of bridge occupied by trains. This load, however, must be regarded as a moving load, travelling gradually across the bridge. As some car of the train would probably be blown over by an 80-mile wind, and as a train therefore would not enter the bridge at such time, it is not necessary to consider the wind pressure on the train at times of maximum wind velocities, although such train area should be considered under the gusty effect of moderate winds.

149. In suspension bridges the effective area of resistance of the main cables and suspenders may be obtained by treating each main cable as a cylinder with a 60% coefficient, and considering it as completely sheltering other cables directly in rear, if touching one to the other, or giving 50% shelter at 2 diameters distance, center to center, but no shelter at 4 diameters distance to either other cables or other parts of the bridge, and by treating each suspender as a cylinder with a 60% coefficient, and considering it as giving no shelter to any other suspenders or other parts of the bridge; so that in bridges of 4,000 ft. length of span the effective wind area of the main cables and suspenders alone may be as much as 8.0 sq. ft. per foot-length of single-track bridge, or 12.0 sq. ft. per foot-length of double-track bridge, and 4.0 sq. ft. per foot-length for each additional track.

150. Total Wind Pressure.—Having found the effective wind area of the span and train and piers, the total pressure to be provided against may be next figured at 30 lbs. per sq. ft. over the entire bridge with a train upon it, or 50 lbs. per sq. ft. over from 600 to 1,000 ft length of the unloaded bridge (including piers), increased by 30 lbs. per sq. ft. over the rest of the unloaded bridge, and then using in subsequent computations whichever of these totals produces the greatest stress upon the particular members under consideration.

151. Arrangement of Wind Bracing.—The wind bracing for ordinary bridges may then be arranged in the form of two horizontal trusses, one above and the other below the roadway, as in the usual arrangement of modern bridges, stiffened by vertical sway bracing. In case of very long bridges, it may be desirable to supplement these by horizontal cables passing under the bridge floor and around the piers and out to the shore anchorages, the versine of the cable being from ⅔ to ¾ the breadth of the piers. In suspension bridges, these two methods are advisably further supplemented by the swinging in or "cradling" of the main cables to such extent that this cradling may be not only enough to support all the wind pressure on the cables and suspenders, but also considerable of that on the stiffening truss and roadway, besides otherwise stiffening the bridge against lateral movement.

152. Dimensioning of Wind Bracing.—The dimensioning of the various parts of the wind bracing may next be computed by the usual methods, the use of the new formulæ of Launhardt and Weyrauch (see par. 104) being recommended as preferable to the older methods, and that of the new dynamic formula of Fidler (see par. 110) as preferable to either. In these computations, especially under either of the new formulæ, it seems hardly necessary because of the infrequency of the maximum stresses to use a coefficient of safety much greater than that actually necessary to make certain that the maximum stress is not allowed at any time to go beyond the minimum elastic limit of such metal as may be naturally expected to actually get into the finished structure, due allowance being made for the ordinary unevenness of manufactured products and the ordinary failures of attempted careful inspection, this minimum elastic limit being deducible from the tests of full-sized members, as well as from those of a large number of smaller pieces, of such metal as it is proposed to use. With ordinary grades of wrought iron and ordinary circumstances of manufacture and inspection, the coefficient of safety may best be taken at 3.5, and the repetition limit at one-half and the reversal limit at one-quarter the ultimate strength of the metal, thus allowing dead-load stresses of 29% and maximum reversal stresses (those under most unfavorable conditions) of 7% of the ultimate strength of the metal; but in exceptional cases of the best steel (bar or wire) and the most careful manufacture and inspection (admitted, however, only after careful tests) it may be allowable to reduce the coefficient of safety to 2.0, and to increase the reversal limit to ⅓ of the ultimate strength, thus allowing dead-load stresses of 50% and maximum reversal stresses (those under most unfavorable conditions) of 17% of the ultimate strength of the metal.

153. In the dimensioning of piers or towers, the breadth of the pier at each of its horizontal sections must be sufficient to prevent the overturning of the pier about either edge of such section, a coefficient of safety of 2.0 being used in the computation of such stability, and the breadth must also be such that no tensional strains shall ever occur in any of the vertical or main posts of the pier.

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PERSONALS.

Mrs. Allen, wife of Mr. Wm. A. Allen, Chief Engineer of the Maine Central R. R., died at Portland, Me., March 4.

Mr. V. Spicer, Signal Engineer of the Union Switch & Signal Co., located at Chicago, Ill., will assume the duties of Western Agent, vice Mr. H. H. McDuffee, resigned.

Mr. F. W. Mahl has been appointed Mechanical Engineer of the Southern Pacific Ry., under the direction of the Superintendent of Motive Power, with offices at Sacramento, Cal.

Mr. Frederick E. Sickels, inventor of an automatic steam cut-off, a steam steering apparatus, and other mechanical apparatus, died at Kansas City, Mo., March 8, at the age of 76.

Mr. Arthur B. Gardner, an assistant engineer with Sooysmith & Co., died at Elmira, N. Y., Feb. 21, after a very brief illness. He was born in 1867, and graduated from the Rensselaer Polytechnic Institute in 1891.

Mr. F. H. Peters has been appointed Chief Engineer, and Mr. J. H. Taylor, Superintendent, of the lines consolidated under the name of the Galveston, La Porte & Houston R. R., with offices at Houston, Tex.

Mr. W. H. Potter has been appointed Superintendent of a division of the Pennsylvania lines west of Pittsburg, with offices at Toledo, O., succeeding the late J. S. Morris. He was formerly Engineer of Maintenance of Way.

Mr. A. A. Stewart, M. Am. Soc. C. E., has been appointed Chief Engineer to the Wilson & Baillie Mfg. Co., of Brooklyn, N. Y., and will have charge of all technical matters relating to the heavy contract work of that company.

Mr. S. R. Tuggle, Superintendent of Motive Power of the Chesapeake, Ohio & Southwestern R. R., has been appointed Superintendent of Motive Power & Machinery of the Houston & Texas Central R. R., with office at Houston, Tex.

Major-General Sir Henry C. Rawlinson, who did much military and exploration work in India and Persia, and deciphered the ancient cuneiform inscriptions found in Persia and Assyria, died March 5. He was many years President of the Royal Geological Society, and was a member of many archaeological and other scientific institutions in Europe and America.

Mr. Henry M. Howe, Past President of the American Institute of Mining Engineers, has been awarded the Bessemer gold medal of the British Iron & Steel Institute in recognition of his work as an engineer and author on steel and the manufacture of steel. The five American engineers who have now received this medal are Messrs. Peter Cooper, A. L. Holley, Abram S. Hewitt, John Fritz, and H. M. Howe.

Mr. Samuel Richards, one of the founders of Atlantic City, N. J., and for many years President of the Camden & Atlantic R. R., died in Philadelphia on Feb. 21. Mr. Richards was born in Philadelphia Aug. 15, 1818, and was the son of Thomas Richards, a merchant of Philadelphia, and of Ann Bartram, a granddaughter of the celebrated botanist, John Bartram, of Bartram's Gardens, Philadelphia. Mr. William Richards, the grandfather of Samuel Richards, was a Revolutionary soldier and the owner of the noted Batsto Iron Works at Batsto, N. J., one of the earliest iron works established in America. Mr. Samuel Richards was the owner of the Jackson Glass Works and an active merchant of Philadelphia until 1852, when he conceived the idea of a railway across New Jersey from Philadelphia to the ocean. He interested some friends in his project, and the first survey was completed by Richard B. Osborne, C. E., on June 18, 1852, for what is now the Camden & Atlantic R. R. Through his influence mainly a charter was obtained on March 10, 1853, for the Camden & Atlantic Land Co., and Atlantic City was started and facilities instituted for establishing cheap excursions and other means of promoting the interests of the railway and the land company. Mr. Richards was president of the land company from its formation; was chiefly instrumental in extending Atlantic City southward by the addition of "Ventnor," and was interested in building the Philadelphia & Atlantic R. R., now part of the Philadelphia & Reading system.

Mr. Charles McFadden, the well-known railway contractor, died at Philadelphia, Pa., last week. He was born at Liverpool, Pa., Dec. 13, 1830, and when 17 years of age began work under his father, who was then a railway contractor. When in business for himself his first contract was on the Littletown branch, now known as the Frederick Division of the Pennsylvania R. R. One of his most important works was the Musconetcong tunnel on the Easton & Amboy R. R. When the Pennsylvania R. R. was first started, Mr. McFadden assisted in building the system through Westmoreland county, Pa., being at that time associated with Mr. Geo. B. Roberts, now President of the road, who was engaged as a civil engineer. When the system was extended to Pittsburg, Mr. McFadden built a large portion of that division. He also built the Alexandria & Fredericksburg in Virginia; a large part of the Pittsburg & Connellsville, now known as the Pittsburg division of the Baltimore & Ohio; the South Penn, which was abandoned before it was completed; the Philadelphia connection on the Pennsylvania system, the Columbia & Port Deposit, the Perkiomen, Cambria & Clearfield system, part of the Huntington & Broad Top, the Brandywine & Waynesburg, the Erie branch of the Pennsylvania from Bradford to Falls Creek, besides several heavy sections on the Schuylkill Valley and Phoenixville branches about 30 miles of the Poughkeepsie Bridge system east of the Hudson River and many of the important branches of the Philadelphia & Reading and Lehigh Valley systems, including a large portion of the latter's extension from Geneva to Buffalo.

ENGINEERING SOCIETIES

COMING TECHNICAL MEETINGS.

ENGINEERS' CLUB OF PHILADELPHIA.
March 16. Secy., L. F. Rondinella, 1122 Girard St.
ENGINEERS' CLUB OF MINNEAPOLIS.
March 18. Secy., E. Nexsen, Kasota Block.
WESTERN RAILWAY CLUB.
March 19. Secy., W. D. Crosman, Club Room 9, Grand Pacific Hotel, Chicago.
COLUMBIAN ENGINEERING SOCIETY.
March 19. Secy., W. F. Hart, University Building, 15th and H. Sts. N. W., Washington, D. C.
ASSOCIATION OF ENGINEERS OF VIRGINIA.
March 20. Secy., J. H. Pilcher, Roanoke, Va.
ENGINEERS AND ARCHITECTS' ASSOCIATION OF SOUTHERN CALIFORNIA.
March 20. Secy., F. Van Vleck, Los Angeles, Cal.
BOSTON SOCIETY OF CIVIL ENGINEERS.
March 20. Secy., S. E. Tinkham, City Hall. Rooms, 36 Bromfield St.
ENGINEERS' CLUB OF ST. LOUIS.
March 20. "European Engineering Schools," by W. S. Chaplin. Secy., W. H. Bryan, Turner Block.
AMERICAN SOCIETY OF CIVIL ENGINEERS.
March 20. "The Topographic Survey of the United States," by H. M. Wilson. Secy., C. W. Hunt, 127 E. 23d St., New York.
CANADIAN SOCIETY OF CIVIL ENGINEERS.
March 21. Secy., C. H. McLeod, 12 Mansfield St., Montreal.
NEW YORK RAILROAD CLUB.
March 21. Secy., John A. Hill, 256 Broadway, N. Y. City.
ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.
March 21. Secy., D. Carhart, Carnegie Library Building, Allegheny.
ENGINEERS' CLUB OF CINCINNATI.
March 21. Secy., J. F. Wilson, Odd Fellows' Temple.
FRANKLIN INSTITUTE, PHILADELPHIA.
March 22. "Submarine Telegraphy," by Prof. A. E. Kennelly. Secy., W. H. Wahl.
INDIANAPOLIS ENGINEERING CLUB.
March 23. Secy., C. C. Brown, City Engineer.
WISCONSIN POLYTECHNIC SOCIETY.
March 26. Secy., W. K. Means, Loan & Trust Building, Milwaukee.
DENVER SOCIETY OF CIVIL ENGINEERS.
March 26. Secy., H. Breen, 36 Jacobson Block.
CENTRAL RAILWAY CLUB.
March 27. Secy., H. D. Vought, Buffalo "Courier," Buffalo, N. Y.
CIVIL ENGINEERS' SOCIETY OF ST. PAUL.
April 1. Secy., C. L. Annan, City Engineer's Office.
ENGINEERING SOCIETY OF WESTERN NEW YORK.
April 1. Secy., Geo. R. Sikes, 122 Pearl St., Buffalo, N. Y.
WESTERN SOCIETY OF ENGINEERS.
April 3. Secy., Chas. J. Roney, 1736 Monadnock Block, Chicago.
TECHNICAL SOCIETY OF THE PACIFIC COAST.
April 5. Secy., O. H. Van Geldern, 319 Market St., San Francisco.
ENGINEERS' CLUB OF KANSAS CITY.
April 8. Secy., F. W. Tuttle, Baird Building.
NORTHWESTERN SOCIETY OF ENGINEERS.
April 9. Secy., D. W. McMorris, Burke Building, Seattle, Wash.
CIVIL ENGINEERS' CLUB OF CLEVELAND.
April 9. Secy., F. C. Osborn, Case Library Building.
NORTHWESTERN RAILWAY CLUB.
Apr. 9. Secy., W. D. Crosman, Ryan Hotel, St. Paul.
NEW ENGLAND RAILROAD CLUB.
April 10. Secy., F. M. Curtis, P. O. Box 1576, Boston, Mass.
ENGINEERS AND ARCHITECTS' CLUB OF LOUISVILLE.
April 11. Secy., Jas. K. Zollinger, Norton Building.
ENGINEERING ASSOCIATION OF THE SOUTH.
April 11. Secy., H. D. Ruhm, Nashville, Tenn.
MONTANA SOCIETY OF CIVIL ENGINEERS.
April 13. Secy., Forrest J. Smith, Denver Block, Helena, Mont.
SOUTHERN AND SOUTHWESTERN RAILWAY CLUB.
April 18. Atlanta, Ga., Secy., F. A. Charpiot, Macon, Ga.
NORTHWESTERN TRACK AND BRIDGE ASSOCIATION.
June 14. Secy., D. W. Meeker, St. Paul, Minn.

ENGINEERS' CLUB OF PHILADELPHIA.—At the meeting on March 2 the promotion of rapid transit in Philadelphia was the subject of a topical discussion opened by Mr. Wm. Wharton, Jr. A number of members took part in the discussion, though little more was accomplished than to point out the difficulties presented by the large area and rectilinear street arrangement of the city.

ASSOCIATION OF ENGINEERS OF VIRGINIA.—At the meeting on Feb. 20 the subject for discussion was "Photography as an Aid to Engineering," opened by Mr. G. R. Henderson, who called attention to the various ways in which photography has been used in the different branches of engineering. At the next meeting, on March 20, a discussion on "The Manufacture of Cement from Furnace Slag" will be opened by Mr. Herman Creuger. John A. Pilcher, Secy.

INDIANAPOLIS ENGINEERING CLUB.—At the meeting on March 9, Mr. C. E. Hildebrand read a paper on "Steel Construction in Architecture," in which he described themost approved methods of constructing the steel frames of modern office buildings, the floor systems and partitions. The next meeting will be held March 23, when Mr. E. Hill will read a paper describing some special construction in the sewer work of Indianapolis last year. Chas. Brown, Sec'y.

WESTERN SOCIETY OF ENGINEERS.—The regular monthly meeting of the society was held at its new quarters in the Monadnock Block, Chicago, on March 6, and consisted of an informal house-warming and conversazione. On March 16 members of the society will visit the Van Buren St. rolling lift bridge and also the Metropolitan West Side Elevated R. R. bridge, on the invitation of City Engineer Samuel G. Artingstall and the engineers of the railway company. A special meeting will be held at Armour Institute March 20, when a paper on the Van Buren St. bridge will be read by Mr. Warren R. Roberts, City Bridge Engineer of Chicago. The paper will be illustrated by stereopticon views prepared by the Institute. This bridge was illustrated and described in our issue of Feb. 21.

CIVIL ENGINEERS' SOCIETY OF ST. PAUL.—At the regular meeting on March 4 a committee on standard wire gages was appointed, and the question of the various U. S. surveys was referred to the committee on the Minnesota state survey. Mr. Truesdell read a paper entitled "The First Engineer," in which he stated that in his opinion the title belonged to Hero (200 B. C.), who was the first to formulate and practically apply the principles of geometry and mechanics, and who also invented methods of land surveying and leveling, and perfected many engines of war and other works. Mr. Crosby described the solution of some of the problems involved in the construction of the 40-ton crane for the Mare Island navy yard.

C. L. Annan, Secy.

NEW PUBLICATIONS.

MARCH MAGAZINES.—"Scribner's" this month contains the first installment of "A History of the Last Quarter Century in the United States," by E. B. Andrews, of Brown University. Under the head of "Railways" two maps are given showing the railways of the United States in 1870 and in 1894, and a photograph of the scene at Promontory Point, Utah, when the last spike of the Union Pacific was driven on May 10, 1869. In "Harper's" Julian Ralph resumes his notes of travel with an account of a trip through Northern Alabama, Tennessee and Georgia, the Southern iron region. Reviewing the recent history of the Southern furnaces, Mr. Ralph expresses the opinion that "there is no decent profit in iron making at a lower price than $10 a ton." The fact is, however, that under the stress of necessity the Southern furnaces most advantageously located have proved their ability to make iron and sell it for very much less than $10 a ton, and still keep their heads above water. Mr. Ralph's review of his journey would have been of greater interest had he visited more of the "boom" towns, which were attracting confiding investors a half a dozen years ago, but which are now practically deserted. His account of Southern industries is compiled too largely from the "Manufacturers' Record" and "The Tradesman" to be taken as an entirely conservative and unbiased report.

In "The Century" Mr. T. C. Martin, of the "Electrical Engineer," has a sketch of the late Hermann von Helmholtz. Another article in this issue worth a passing notice here is a paper entitled "Blackmail as a Heritage, or New York's Legacy from Colonial Days." The author examines the theory that municipal corruption in Gotham is to be ascribed to the customs of colonial days, when a goodly proportion of the residents on Manhattan Island made a living by privateering, smuggling and other picturesque occupations.

The "Review of Reviews" this month has portraits of the retiring president and the recently elected president of the American Society of Civil Engineers, Col.

Craighill and Mr. Geo. L. Morison, and of Col. Geo. E. Waring, Jr. There is also an excellent illustrated article on the electric street railways of Budapest. A very pertinent editorial note draws the contrast between the splendid triumphs of architecture in the short-lived structures of the Columbian Exhibition and the monstrosities of government and municipal architecture in this country, the most colossal example of gilded ugliness in the latter category being Philadelphia's great city hall, of which an engraving is presented.

In the "Popular Science Monthly" the processes of copper and steel engraving are described by C. W. Dickinson, Jr. It is interesting to note that there are only three or four first-class operators of the geometric lathe in the world, and they are all Americans. Dr. Bela Hubbard writes on "The Lesson of the Forest Fires," and there is an illustrated account of Weilner's wheel-sail flying machine.

In the "North American Review" Stockton Bates tells how he would prevent strikes and lockouts. Briefly stated, his remedy is to increase the strength of labor organizations until they shall comprise the whole number of workers for wages. At the same time, he would "sweep from the constitution and by-laws of labor unions every vestige of restriction and brute force," and would have them use the money now spent in strikes in co-operative production, by acquiring an interest in railway, mining and manufacturing companies.

In the "Forum" Prof. F. W. Blackmar describes the successful experience with profit-sharing of the Proctor & Gamble Co. at Ivorydale, near Cincinnati, and by the N. O. Nelson Mfg. Co., of St. Louis. Dr. B. G. Northrop has an interesting paper on "Village Improvement Societies, and Mr. Jacob A. Riis discusses with much force the recent report of the New York City Tenement House Commission.

CONSTRUCTION NEWS.

CONDENSED LIST OF CONTRACTS PENDING WITH DATE OF OPENING BIDS.

Bids to be opened.	Work.	Place.	See Eng. News.
Mar. 15.	Sewers (7 miles),	Bristol, Conn.	Feb. 14
	Advertised, Eng. News, Feb. 14 to Feb. 28.		
Mar. 15.	Water-works system,	Port Hope, Ont.	Feb. 14
Mar. 15.	Pipe sewers,	Hamilton, O.	Feb. 21
Mar. 15.	Pipe sewers,	Richmond, Ind.	Feb. 28
Mar. 15.	Brick walks, etc.,	Richmond, Ind.	Feb. 28
Mar. 15.	Bridge,	Black River Falls, Wis.	Mar. 7
Mar. 15.	Bridge,	Melrose, Wis.	Mar. 7
Mar. 15.	Sewer,	Avondale, O.	Mar. 7
Mar. 16.	Water-works system,	Evanston, O.	Feb. 21
Mar. 16.	Stone chapel,	Lancaster, O.	Feb. 21
Mar. 16.	Granite blocks,	Louisville, Ky.	Feb. 28
Mar. 16.	Electric motors,	Cleveland, O.	Mar. 7
Mar. 16.	Jetty work,	Portland, Ore.	Mar. 7
Mar. 16.	Sewers,	Pittsburg, Pa.	Mar. 7
Mar. 16.	Paving, etc.,	Pittsburg, Pa.	Mar. 7
Mar. 16.	Street signs,	Pittsburg, Pa.	Mar. 7
Mar. 16.	Sewer brick,	Boston, Mass.	Mar. 14
Mar. 16.	Steel rails (10,000 tons),	San Francisco.	Mar. 14
Mar. 18.	Steel bridge,	Atlanta, Ga.	Feb. 14
	Advertised, Eng. News, Feb. 14 to 28.		
Mar. 18.	Pumping engines,	Sacramento, Cal.	Feb. 21
Mar. 18.	Water bonds,	Caldwell, Idaho.	Feb. 28
Mar. 18.	Electric light bonds,	Caldwell, Idaho.	Feb. 28
Mar. 18.	Brick pav'g (3,600 sq. yds.),	Atlanta.	Mar. 7
Mar. 18.	Cast iron pipe,	Cambridge, Mass.	Mar. 7
Mar. 18.	Pile bridges,	Seward, Neb.	Mar. 7
Mar. 18.	Bridge,	Columbus, Tex.	Mar. 7
Mar. 18.	Building,	Atlanta, Ga.	Mar. 7
Mar. 18.	Water-wks. system,	Sparta, Wis.	Mar. 14
Mar. 18.	Asphalt paving,	St. Paul, Minn.	Mar 14
Mar. 18.	Hose wagons, etc.,	Cincinnati, O.	Mar. 14
Mar. 18.	Water tower,	Toronto, Ont.	Mar. 14
Mar. 18.	Stop-cocks,	Boston, Mass.	Mar. 14
Mar. 18.	Water bonds,	Brockville, Ont.	Mar. 14
Mar. 19.	Drains,	Mount Morris, Mich.	Feb. 14
Mar. 19.	Iron fence, etc.,	Riverside, O.	Feb. 21
Mar. 19.	Electric lighting,	Whitewater, Wis.	Feb. 14
Mar. 19.	County bridges,	Muscatine, Ia.	Feb. 28
Mar. 19.	Sewer,	Tallahassee, Fla.	Feb. 28
Mar. 19.	Water-works,	Muscatine, Ia.	Feb. 28
Mar. 19.	Water-works system,	Cuthbert, Ga.	Feb. 28
	Advertised, Eng. News, Mar. 7.		
Mar. 19.	Supplies for navy y'd at	Norfolk, Va.	Mar. 7
Mar. 19.	Supplies for navy y'd,	Was'gton, D. C.	Mar. 7
Mar. 19.	Supplies for navy y'd at	Brooklyn.	Mar. 7
Mar. 19.	Water-works system,	Cadiz, O.	Mar. 7
Mar. 19.	Steel liberty pole,	Buffalo, N. Y.	Mar. 7
Mar. 19.	Pipe sewers (7,840 ft.),	Hamilton, O.	Mar. 7
Mar. 19.	Fire engines, hose, etc.,	Baltimore.	Mar. 7
Mar. 19.	Artificial stone sidew'k,	Fern Bank, O.	Mar. 7
Mar. 19.	Improving building,	Albany, N. Y.	Mar. 14
Mar. 19.	Granite curbing,	Holyoke, Mass.	Mar. 14
Mar. 19.	Pipe sewers (7,465 ft.),	Providence.	Mar. 14
Mar. 19.	Electric light bds,	Grand Rapids, Mich.	Mar. 14
Mar. 20.	Water bonds,	Port Hope, Ont.	Feb. 28
Mar. 20.	Bridge bonds,	New Westminster, B. C.	Feb. 28
Mar. 20.	Subway,	Boston, Mass.	Feb. 21
	Advertised in Eng. News, Feb. 21 to Mar. 7.		
Mar. 20.	Power house, etc.,	Toledo, O.	Feb. 21
Mar. 20.	Dredging & rem'g rock,	Newport, R. I.	Feb. 21
	Advertised, Eng. News, Feb. 21 to Mar. 14.		
Mar. 20.	Paving (10 streets),	Cleveland.	Feb. 21
Mar. 20.	Building at	Atlanta, Ga.	Mar. 7
Mar. 20.	Sewers,	Cleveland, O.	Mar. 7
Mar. 20.	Gravel, etc.,	New York, N. Y.	Mar. 14
Mar. 20.	City hall,	Lansing, Mich.	Mar. 14
Mar. 20.	Pipe sewers,	Petersburg, Va.	Mar. 14
Mar. 20.	Sewers,	New York, N. Y.	Mar. 14
Mar. 20.	Grading, etc.,	Cleveland, O.	Mar. 14
Mar. 20.	Sewers (15 contracts),	Louisville, Ky.	Mar. 14
Mar. 20.	Grading (900,000 cu. yds.),	St. Louis.	Mar. 14
	Advertised, Eng. News, Mar. 7 and 14.		
Mar. 21.	Gravel roads,	Anderson, Ind.	Feb. 21
Mar. 21.	Electric lighting,	Meridian, Miss.	Feb. 14
	Advertised, Eng. News, Feb. 14 to Mar. 14.		
Mar. 21.	Jail,	Lawrenceville, Ill.	Mar. 7
Mar. 21.	Pipe sewers (9,000 ft.),	Westport, Mo.	Mar. 7
	Advertised, Eng. News, Mar. 7.		
Mar. 21.	Light stations,	Detroit, Mich.	Mar. 14
Mar. 21.	Bridge piers,	Providence, R. I.	Mar. 14
Mar. 21.	Carbons,	Jacksonville, Fla.	Mar. 14
Mar. 22.	Public building at	Sioux City, Ia.	Mar. 7
Mar. 23.	Dredging,	Montgomery, Ala.	Feb. 21
	Advertised Eng. News, Feb. 21 to Mar. 14.		
Mar. 22.	Electrical supplies,	Baltimore, Md.	Mar. 14
Mar. 22.	Telford paving,	Newark, N. J.	Mar. 14
Mar. 22.	Electrical materials,	Philadelphia, Pa.	Mar. 14
	Advertised, Eng. News, Mar. 14 and 21.		
Mar. 23.	Cement,	Montgomery, Ala.	Feb. 21
	Advertised, Eng. News, Feb. 21 to Mar. 14.		
Mar. 23.	Canal (6½ miles)	Ottawa, Ont.	Feb. 21
Mar. 23.	Sewer bonds ($50,000),	Cleveland, O.	Feb. 28
Mar. 23.	Brick paving,	Cincinnati, O.	Feb. 28
Mar. 23.	Office building,	Pittsburg, Pa.	Mar. 7
Mar. 23.	Paving (11,400 sq. yds.),	Marion, O.	Mar. 7
Mar. 23.	Masonry abutments,	Denver, Colo.	Mar. 14
Mar. 23.	Removal of wreck,	Philadelphia.	Mar. 14
Mar. 23.	Brick paving,	Indianapolis, Ind.	Mar. 14
Mar. 25.	Water bonds,	Evanston, O.	Feb. 28
Mar. 25.	Water bonds,	Winton Place, O.	Feb. 28
Mar. 25.	Dam, etc.,	Cambridge, Mass.	Feb. 28
	Advertised Eng. News, Feb. 28 and Mar. 7.		
Mar. 25.	Water bonds,	Evanton, O.	Feb. 28
Mar. 25.	Street improvements,	Streator, Ill.	Mar. 7
Mar. 25.	Pipe sewers (88,881 ft.),	Pl'nfield, N. J.	Mar. 7
	Advertised, Eng. News, Mar. 7.		
Mar. 25.	Water bonds,	Hanover, Kan.	Mar. 7
Mar. 25.	Water-works system,	Hanover, Kan.	Mar. 7
Mar. 25.	Bridge,	Yonkers, N. Y.	Mar. 7
Mar. 25.	Lighting,	Helena, Mont.	Mar. 14
Mar. 25.	Water supply,	Jersey City, N. J.	Mar. 14
Mar. 25.	Brick paving,	Zanesville, O.	Mar. 14
Mar. 25.	Asphalt paving,	Jersey City, N. J.	Mar. 14
Mar. 26.	Street impvt. bonds,	Pleasant Ridge, O.	Feb. 28
Mar. 26.	Dredging plants,	Pittsburg, Pa.	Feb. 28
Mar. 26.	Steel bridge,	Denver, Colo.	Mar. 7
	Advertised, Eng. News, Mar. 7.		
Mar. 26.	Supplies for navy y'd,	Mare Isl., Cal.	Mar. 7
Mar. 26.	Macadamizing,	Glencoe, Ill.	Mar. 14
	Advertised Eng. News, Mar. 14.		
Mar. 27.	Plans for school bldg.,	Milwaukee, Wis.	Feb. 7
Mar. 27.	Smokestack, etc.,	Toledo, O.	Feb. 21
Mar. 27.	Bridge,	Toledo, O.	Feb. 28
Mar. 27.	Stone paving,	Cleveland, O.	Feb. 28
Mar. 27.	Dam, etc.,	Woonsocket, R. I.	Mar. 7
	Advertised, Eng. News, Mar. 7 to 21.		
Mar. 27.	Approach to pub. bldg.,	Lowell, Mass.	Mar. 14
Mar. 28.	Channel work,	New Orleans, La.	Mar. 7
Mar. 28.	Court house bonds,	Troy, N. Y.	Mar. 14
Mar. 29.	Bridge bonds,	Winnipeg, Man.	Feb. 21
Mar. 29.	Elevators for pub. bldg.,	New York.	Mar. 7
Mar. 29.	Curbing, etc.,	Richmond, Ind.	Mar. 14
Mar. 29.	Pipe sewers (3 miles),	Roselle, N. J.	Mar. 14
	Advertised, Eng. News, Mar. 14 and 21.		
Mar. 30.	Water-works system,	Pawling, N. Y.	Feb. 28
	Advertised, Eng. News, Feb. 28 to Mar. 21.		
Mar. 30.	Pipe sewers (14,772 ft.),	Marion, O.	Mar. 7
Mar. 30.	Wharfwork at	Blackbeard Island, Ga.	Mar. 14
Mar. 30.	Building shops,	Pittsburg, Pa.	Mar. 14
Mar. 30.	Sidewalks,	Houston, Tex.	Mar. 14
Mar. 30.	Sewer,	Sandusky, O.	Mar. 14
Apr. 1.	Brick paving (20,000 yds.),	Newark, O.	Feb. 21
Apr. 1.	Sewer,	Keokuk, Ia.	Feb. 28
	Advertised Eng. News, Feb. 28 and Mar. 7.		
Apr. 1.	Water bonds,	Bancroft, Ia.	Feb. 28
Apr. 1.	Tunnel sewer,	Keokuk, Ia.	Feb. 28
	Advertised Eng. News, Feb. 28 and Mar. 7.		
Apr. 1.	License to cut timber,	Toronto, Ont.	Mar. 7
Apr. 1.	Granite block pav'g,	Cincinnati, O.	Mar. 7
Apr. 1.	Water-wks. supplies,	Oil City, Pa.	Mar. 7
Apr. 1.	Revetment work,	Duluth, Minn.	Mar. 7
Apr. 1.	Steel forgings,	Washington, D. C.	Mar. 14
Apr. 1.	Barracks,	Omaha, Neb.	Mar. 14
Apr. 1.	Main sewer,	Jefferson City, Mo.	Mar. 14
	Advertised, Eng. News, Mar. 14.		
Apr. 2.	Dredging,	Boston, Mass.	Feb. 28
	Advertised Eng. News, Feb. 28 to Mar. 21.		
Apr. 2.	Brick paving,	Waukegan, Ill.	Mar. 14
	Advertised, Eng. News, Mar. 14 and 21.		
Apr. 4.	Water bonds,	Norwood, O.	Mar. 7
Apr. 4.	B'kwater w'k, etc.,	G'nd Rapids, Mich.	Mar. 14
Apr. 4.	Constructing bldg,	Plattsburg, N. Y.	Mar. 14
Apr. 4.	Brick paving,	Peoria, Ill.	Mar. 14
	Advertised, Eng. News, Mar. 14.		
Apr. 4.	Water-works system,	Celina, O.	Mar. 14
Apr. 5.	Dredging,	Wilmington, Del.	Mar. 14
	Advertised, Eng. News, Mar. 14 to Apr. 4.		
Apr. 5.	Electric light plant at	Milwaukee, Wis.	Feb. 28
Apr. 5.	Heat'g & vent'g app't's,	St Louis.	Mar. 7
Apr. 8.	Bridge bonds ($200,000),	Portland, Ore.	Mar. 14
Apr. 8.	Jail,	Williamson, W. Va.	Mar. 14
Apr. 8.	Sewers (27 miles),	Champaign, Ill.	Mar. 14
	Advertised, Eng News, Mar. 7 to Apr. 5.		
Apr. 9.	Water-wks. system,	Seneca, Kan.	Mar. 7
	Advertised, Eng. News, Mar. 7.		
Apr. 10.	Buildings at	Fort Mever, Va.	Mar. 14
Apr. 15.	Sewer bonds,	South Orange, N. J.	Mar. 14
May 15.	Plans, etc., for bridge,	Montreal	Jan. 24
	Advertised, Eng. News, Jan. 24 and 31.		
May 20.	Water bonds,	Santa Clara, Cal.	Mar. 7
	Advertised, Eng. News, Mar. 7 to 28.		
May 23.	Water-wks. system,	Santa Clara, Cal.	Mar. 7
	Advertised, Eng. News, Mar. 7 to 28.		
No date.	Railway (300 miles),	Palestine, Tex.	Mar. 14
	Advertised, Eng. News, Mar. 14.		
"	Dynamo, Water Valley,	Miss.	Mar. 14
"	Pipe, hydrants ,etc.,	Norman, Okla.	Mar. 14

RAILWAYS.

East of Chicago.

CARTHAGE & ADIRONDACK.—W. J. Spencer, of Watertown, N. Y., is reported to have been awarded the contract for the construction of a branch of this road from Benson Mines to Newton Falls, 3½ miles. This railway is operated as a part of the Rome, Watertown & Ogdensburg division of the New York Central system.

CHICAGO & WEST MICHIGAN.—Grand Rapids, Mich., papers state that this company has decided to abandon its old road to Lake Harbor and will spend $12,000 in building a new line behind the bluffs where the storms cannot wreck the system every few weeks.

EASTERN CENTRAL.—Efforts are being made to secure the early construction of this railway. Two years ago the line was surveyed by R. H. Lee, Ch. Engr., Londonville, O., from Yellow Creek, O., to Galion, O., 140 miles, and steps were being taken to continue the line from Galion to Lafayette, Ind., 220 miles. Pres., Dan Babst, Jr., Crestline, O.; Vice-Pres., Martin Deal, Bucyrus, O.

FARMINGTON, WATERVILLE & WISCASSET.—H. B. Goodenough, of Brighton, Mass.; V. B. Mead, of Boston; N. B. Beal, of Phillips, Me.; W. F. P. Boss, of Waterville, Me.; P. H. Stubbs, of Strong, Me., and others have petitioned for a charter for this company, which proposes to build a steam or electric railway from Waterville, Me., through the towns of Oakland, Belgrade, Smithfield, Rome, Mercer, and New Sharon, to Farmington; preliminary surveys to be made by Dec. 31, 1895, and the road completed by Dec. 31, 1896; capital stock, $100,000.

FLINT & PERE MARQUETTE.—Press reports state that the contract for the building of the extension of this railway from a point south of Carleton to Toledo has been let to Detroit parties, and work will be begun as soon as the weather will permit. Over $100,000 has been expended for the right of way. The route will be used by the Pennsylvania and other eastern lines to gain an entrance to Detroit. An official of the company states that this report is incorrect, and that nothing has been done for some time in regard to this proposed extension. Ch. Engr., W. B. Sears, Saginaw, Mich.

LANCASTER, OXFORD & SOUTHERN.—Walter Franklin, Pres., Lancaster, Pa., writes us that the newspaper reports in regard to proposed extensions are premature, and that there is no prospect of an early extension of this road.

McFADEN COAL CO.—This company is about to develop a large coal field in Jefferson county, O., and will soon construct a railway 3½ miles in length from the mines to the Pittsburg, Cincinnati, Chicago & St. Louis road near Miller station. Engr., S. A. Taylor, Wilkinsburg, Pa.

NORWALK & NORTHFIELD.—Press reports from Norwalk, O., state that the long-talked-of interuban railway between Norwalk and Northfield, 10 miles, will soon be built by ex-Mayor S. E. Crawford and other Norwalk and Fairfield capitalists. The road will be standard gage, and will be operated by the H. K. Porter noiseless steam motors. The projectors ask $5,000 as a donation for preparing roadbed. The road will be in operation by July 4, 1895.

PENNSYLVANIA.—Wm. H. Brown, Ch. Engr., writes us that there will be no extensions of this railway this summer until the times are better.

SHERMAN & PATTEN.—A. A. Burleigh, Pres. Bangor & Aroostook, Houlton, Me., is reported as organizing a company to build a railway from some point on the Bangor & Aroostook to Patten, Me., and it is thought that the road will be built early this summer.

SOUTHBRIDGE, STURBRIDGE & BROOKFIELD.—L. M. Thacher, Cy. Engr., Northampton, Mass., is relocating about seven miles of this railway, which is projected from Southbridge to Brookfield, Mass., a distance of 13 miles. Bids for building the entire road were received by Frederick D. Fish, Pres., 87 Milk St., Boston, March 9, 1894, but no contracts were awarded.

TOLEDO & OHIO CENTRAL.—This company is reported to have negotiated an issue of $2,000,000 in bonds, including $400,000 for Columbus terminals and extensions.

TORONTO, HAMILTON & BUFFALO.—Tracklaying on this railway has been completed between Brantford and Hamilton, Ont., and this portion of the line will be opened for traffic in a few days.

Southern.

ATLANTIC COAST LINE.—Surveys are reported as being made for a branch about six miles long in North Carolina, to connect the Charleston, Sumter & Northern division with the main line.

BRISTOL, ELIZABETH & NORTH CAROLINA.—Judge Hugh Kyle has ordered the sale of this railway, which has been in the hands of receivers for some months.

CHESAPEAKE, SHENDUN & WESTERN.—E. C. Macken, Pres. Old Dominion Construction Co., 1 Broadway, New York, has paid the charter fee of $200 for the charter granted to this company by the Virginia general assembly at its last session; incorporators, Jed Hotchkiss, H. M. Bell, M. Erskine Miller and J. N. Stubbs; capital stock, $10,000,000. The proposed route of the road is from some point between the Potomac and the York rivers to the West Virginia line.

CUYLER & WOODBURY.—This railway was completed in Georgia last week, according to reports. It is 14 miles in length, and has been built chiefly by J. N. Wood, of Greig, Jones & Wood, Savannah, and of Wood & Co., Pinora, Ga.

KNOXVILLE JUNCTION TERMINAL & BELT.—Col. Albert E. Boone, of Zanesville, O., appeared before the Knoxville, Tenn., chamber of commerce last week in the interest of this projected railway and a double-track line from Jellico to Port Royal, S. C.

LEXINGTON TERMINAL.—It is reported that this railway, at Lexington, Ga., will soon be extended to Smithsonia, a distance of about 13 miles.

NASHVILLE, TENN.—The council is considering the question of building a standard gage railway to the new water-works pumping station, at an estimated cost of $10,000 to $20,000.

SOUTHPORT & CONWAY.—E. B. Stevens, of Southport, N. C., is reported as interested in a company that has petitioned for a charter to build a railway from Southport to Conway, N. C.

Northwest.

CHICAGO & NORTHWESTERN.—A press report from Deadwood, S. Dak., states that this company has a large force of men surveying the country northwest of Belle Fourche, and it is probable that it will extend its road into Montana and the cattle country this summer.

TERRE HAUTE, SAYLOR SPRINGS & MOUNT VERNON.—Press reports from Terre Haute, Ind., state that W. L. Elseper, an expert railway engineer, started from that city March 7 for Mount Vernon, Ill., over the proposed route of this railway. He goes as the representative of English capitalists, from whom a loan of $2,000,000 has been solicited.

Southwest.

LINK LINE.—Press reports state that the following contracts were awarded March 6: Illinois Steel Co., 150 miles of rails; Pittsburg Locomotive Works, 10 locomotives, 2 to be delivered immediately; Madison (Ill.) Car Works, 100 freight cars; J. A. Ware, of St. Louis, and J. S. McNamara, of San Antonio, contracts for grading 130 miles; Hopkins Construction Co., of St. Louis, 11 steel bridges; W. C. Carlton, of Georgetown, Tex., (or W. E. Carroll, of Dallas, according to another report), wooden bridges and piling.

LITTLE ROCK & PACIFIC.—The contract for the first 20 miles of this railway has been awarded to R. M. Quigley & Co., as noted last week. It is now stated that the entire 230 miles will be put under contract within 30 days. Pres., W. M. Fishback, Little Rock, Ark.

MISSOURI, KANSAS & TEXAS.—Work was commenced March 7 clearing off the site for a new $30,000 station at Sedalia, Mo. It is stated that the yards will be enlarged and additional coal chutes erected.

ST. LOUIS & KANSAS CITY.—Incorporated in Missouri March 4 to build a railway from Green Ridge to Kansas City, 115 miles; capital stock, $1,150,000; incorporators, R. M. Maguire, J. H. Hill, J. M. Bryson, F. A. Leland and Jas. Hagerman, all of St. Louis. Press reports state that this road will be part of the Missouri, Kansas & Texas system. It will not be built at present to Kansas City, but only from Green Ridge to Holden. From Holden to Paola the M., K. & T. has a line of its own, now leased to the Missouri Pacific, and from Paola it runs into Kansas City over the Kansas City, Fort Scott & Memphis tracks, operating its own trains, however, and having all the rights of a proprietary road. The completion of the road will give the M., K. & T. a line from St. Louis to Kansas City.

SAN ANTONIO & BROWNSVILLE.—The incorporation of this company was noted in our issue of Feb. 14. It is reported that an active canvass for subscriptions is being made at San Antonio, Tex., and that surveys for the proposed road will be commenced April 15. J. S. Doak and J. M. Puett, of San Antonio, are interested.

SAN ANTONIO & GULF.—A press report from San Antonio, Tex., March 4, states that a large force of men were on that day put to work constructing the San Antonio & Gulf Shore Ry. About 25 miles of this line was completed a few months ago, and is now in operation, but trouble between the two factions striving for the management of the property caused an interruption of the work. Henry Terrell was appointed receiver of the road a few weeks ago, but he has not yet taken charge of the property, as there is an appeal pending in the court of civil appeals. The contract has been let for the building of the entire line, from its present terminus to Velasco. Pres., W. Davis, San Antonio, Tex.

WACO, PALESTINE & ALEXANDRIA.—W. B. Johnson, Palestine, Tex., wants to correspond with railway contractors who can build 100 to 300 miles of railway, as stated in our advertising columns. In a letter from Mr. Johnson, published Nov. 22, 1894, he stated that it was thought that the entire road could be built from Waco, Tex., to Alexandria, La., 300 miles, for about $9,000 a mile.

Rocky Mt. and Pacific.

GREAT FALLS & CANADA.—It is reported that work will be commenced about May 1 on a branch of this railway from Collins, Mont., to the Curton Colony. Pres., E. T. Galt; Supt., W. D. Barclay, both of Great Falls, Mont.

GREAT SALT LAKE & HOT SPRINGS.—The contract for grading the five-mile extension from Centerville to Farmington has been awarded to Saunders & Heiss. It is expected to have the line completed next month. Ch. Engr., H. S. Joseph, Salt Lake City, Utah.

SAN FRANCISCO & SAN JOAQUIN VALLEY.—Bids are asked until March 16 for 10,000 tons of steel rails; the first lot of 2,000 tons must be shipped within 30 days of the date of acceptance of the bid. It is estimated that 10,000 tons of rails will lay 100 miles of track, and that about 33,000 tons of rails will be required to build the line as contemplated. Claus Spreckles is interested.

SANTA CLARA VALLEY RY. & NAVIGATION CO.—Incorporated in California March 6 to build a standard gage railway 77 miles in length, and to operate railways and steamship lines between Alvis and San Francisco; capital stock, $1,540,000, commencing with $77,770; incorporators, Geo. F. Smith, Lewis A. Sage, W. P. Hurley, W. O. Watson and V. Koch, all of Santa Clara county, Cal.; principal place of business, San Jose, Cal.

UTAH & PACIFIC.—Incorporated in Iowa Feb. 20 by S. M. Casey and Geo. R. Stewart, representing parties who will build a standard gage railway from Marysvale, Piute county, Utah, the terminus of a proposed Rio Grande Western extension, to San Bernardino county, Cal., to a connection with the Atlantic & Pacific; capital stock, $5,000,000.

STREET AND ELECTRIC RAILWAYS.

PORTLAND, ME.—The Portland R. R. Co. has awarded contracts for equipping about 12 miles of its road with electricity, work on which will probably begin April 1. The power house will be at Deering Bridge, and will contain two engines of 800 HP. each. Supt., E. A. Newman.

BENNINGTON, VT.—The Bennington & Woodford Electric R. R. Co. proposes to begin the construction of its road between this village and Camp Comfort, a distance of four miles, in about a month. The road, which will follow the old roadbed of the abandoned Bennington & Glastonbury R. R., will be operated only in summer. The company has purchased four cars and two dynamos. The power will probably be furnished by the Bennington Electric Light Co. Pres., C. W. Crispill, Nyack, N. Y.; Vice-Pres. and Gen. Man., H. W. Martin; Secy., C. H. Mason.

BRATTLEBORO, VT.—The state railroad commissioners have granted the Brattleboro St. Ry. Co. right of way in this city for its electric road.

ARLINGTON, MASS.—The construction of an electric railway to connect this place with Winchester, a distance of six miles, is again being discussed. It is estimated that the equipment will cost about $40,000, and the construction about $10,000, a mile. A. B. Coffin, D. N. Skillings and J. H. Winn have been appointed as a committee to secure information.

BEVERLY, MASS.—The Beverly, Essex & Gloucester St. Ry. Co. has petitioned for a franchise for its electric road. W. B. Ferguson, of Malden, is interested.

DARTMOUTH, MASS.—The Dartmouth & Westport St. Ry. Co. has been authorized to increase its capital stock $50,000 and issue $90,000 in bonds for constructing and equipping its road with electricity.

DIGHTON, MASS.—The Taunton, Somerset & Swansea St. Ry. Co. has been granted a franchise in this place and Somerset.

FITCHBURG, MASS.—The Fitchburg & Leominster St. Ry. Co. has been granted a franchise for its electric road from North Leominster to Lunenburg.

STOUGHTON, MASS.—The Stoughton & Canton St. Ry. Co. has been incorporated to complete the link between the Brockton line at Stoughton and the new line from Canton and Sharon; incorporators, Henry W. Britton, E. C. Monk, H. L. Johnson and Geo. E. Belcher.

WEYMOUTH, MASS.—The Weymouth & Braintree St. Ry. Co. has accepted the location granted it by the selectmen for the extension of its electric road. The capital stock will be increased to $160,000 for the extension and for building a $25,000 power house.

AUBURN, N. Y.—The Auburn Cy. Ry. Co. is considering the question of extending its electric road to Geneva, Skaneateles and Syracuse. Pres., C. D. Beebe. Thos. Craig, Pres. Seneca Falls & Waterloo Ry., is interested.

BATH-ON-HUDSON, N. Y.—The trustees are considering the question of granting a franchise for an electric railway to Castleton and a branch to Greenbush.

BUFFALO, N. Y.—The Hamburg Electric Ry. Co. has been incorporated to build a railway between this city and Hamburg, a distance of about nine miles. The road is estimated to cost $100,000. Among those interested are William Elwood, John O'Brian, S. H. Knoopmans, L. L. Long, James E. Curtiss, R. L. Banta, of Buffalo, and Thomas L. Bunting, George M. Pierce, Jacob Peffer, H. S. Spencer, of Hamburg.

COHOES, N. Y.—The Cohoes City Ry. Co. has awarded the contract for rails for the extension of its electric railway. All material for the construction of the road will be purchased by the company, but the building of the roadbed will be done by contract. It is reported that when this extension is completed Wm. H. Gwynne, of the Cataract House, proposes to build a line down along the river.

HERKIMER, N. Y.—The reconstruction of the Herkimer, Mohawk, Ilion & Frankfort Electric Ry. and the extension of the road from Frankfort to Utica will begin as soon as the weather permits.

MOUNT VERNON, N. Y.—The North Mount Vernon Ry. Co. is about to extend its road from this place to New Rochelle and White Plains, and from New Rochelle to Tuckahoe.

SCHENECTADY, N. Y.—A correspondent writes us that the Schenectady St. Ry. Co. is about to reconstruct about 4,800 ft. of its road on State St. Gen. Man., H. S. Cooper.

WHITE PLAINS, N. Y.—Press reports state that the New York, Elmsford & White Plains Ry. Co. has accepted the franchise granted by the trustees to operate an electric road through the village. The company already has a franchise from Greenburg to build from Elmsford, on the New York & Putnam R. R., to the village line. The road will eventually connect the Hudson River, Putnam, Harlem and New Haven railroads, besides connecting with the extensions of the Yonkers and Huckleberry electric roads, as well as the roads recently organized to operate along the Sound.

HADDONFIELD, N. J.—The West Jersey Traction Co. has been granted a 25-year franchise for its electric road on all the streets of this place.

JERSEY CITY, N. J.—The International Terminal Ry. Co. has been incorporated to build a street railway from Walker Ave., Jersey City to Oyster Island, on New York Bay; capital stock, $1,500,000; incorporators, Dan'l S. Appleton, of New York; Solon Humphreys, of Bergen Point, N. J.; D. Pritchard, of East Orange, N. J., and Geo. W. Murray, of Montclair.

LONG BRANCH, N. J.—The Sea Shore Electric Ry. Co. has petitioned for a franchise for its road from Asbury Park to Long Branch.

ALTOONA, PA.—The City Passenger Ry. Co. has been granted permission to extend its electric road, work on which will soon begin. Supt., C. L. West.

HAZELTON, PA.—Press reports state that as a result of the competition between the electric roads and the Lehigh Valley R. R. Co. between here and Freeland the latter has decided to take off some of its trains. The electric railway people are now preparing to extend their tracks to Stockton and Beaver Meadow.

PHILADELPHIA, PA.—The Philadelphia & Paoli Ry. Co. has been incorporated, with a capital stock of $500,000, by John H. Wanner, 4,040 Powelton Ave.

PITTSBURG, PA.—Press reports state that an electric railway scheme is being considered to connect Greensburg, West Newton, McKeesport and Pittsburg. The promoters of the enterprise are ex-Judge Sadler and Millard F. Thomas, of Carlisle. It is quietly hinted, however, that the Widener-Elkins syndicate, which controls the Philadelphia and Pittsburg traction roads, is back of the movement. The electric line from Greensburg to Hempfield has been bought for $50,000. It is two miles in length, and will be extended to West Newton and thence to McKeesport. At McKeesport it will use the tracks of the McKeesport, Duquesne & Wilmerding through that city to Duquesne and Homestead. From Homestead it will enter this city by way of the new bridge at Brown's Station and the Homestead & Highlands Co.'s tracks. A mortgage of $500,000 on the road has been filed in favor of the Union Trust Co. Bonds to that amount will be issued for the building of the road, and it is to be completed by July 1.

WILMINGTON, DEL.—The Newcastle & Wilmington Electric Ry. Co. has been granted authority to extend its road to the mouth of the Christiana River and to Farnhurst. A bridge will be built over the railway at Newcastle.

ANNAPOLIS, MD.—The Baltimore, Westport & Annapolis Electric Ry. & Tramway Co. has been incorporated; capital stock, $100,000; incorporators, Henry Y. Bready, A. C. F. Boehme, Jr., and O. Parker Baker, of Baltimore.

BALTIMORE, MD.—A proposition has been made to the Baltimore & Jerusalem Turnpike Co. by an electric railway company for extending its line on the Belair Road from the city limits for a distance of four miles.

RICHMOND, VA.—W. F. Jenkins has petitioned for a franchise for a conduit electric railway, recently invented by him.

CHARLESTON, W. VA.—The Charleston St. Ry. Co. has been incorporated to build an electric railway to West Charleston, a distance of about five miles. Work will begin about April 1.

NEW ORLEANS, LA.—E. M. Hudson has petitioned for a franchise for an electric railway on about 60 miles of streets in this city.——W. H. Watkins has been granted a franchise for an electric railway on several streets.

NASHVILLE, TENN.—The Belmont St. Ry. Co., recently incorporated, has petitioned for a franchise.

BIRMINGHAM, O.—The Milan, Birmingham & Elyria Electric Ry. Co. has been incorporated to build a road between Milan, Birmingham, Elyria, Florence and Henrietta, with branches to North Amherst, Oberlin, Wellington and Huron; capital stock, $100,000; incorporators, Geo. W. Clary, G. P. Baker, H. P. Starr, H. D. Olds, John R. Carter and F. Burk.

CINCINNATI, O.—W. E. Hutton & Co. have bid $30,000 cash and 5% of the gross earnings for a 25-year franchise over the route now occupied by the tracks of the Mount Auburn Inclined Plane Ry. Co. ——The Consolidated St. Ry. Co. has applied for permission to extend its electric road from Anderson's Ferry through Delhi, Home City and Addyston. Pres., John Kilgour.

COLUMBUS, O.—The Crosstown St. Ry. Co. has been granted permission to extend its electric road. Gen. Man., W. F. Kelley.

DAYTON, O.—The City Ry. Co. has petitioned for permission to extend its road. Supt., A. W. Anderson.

IRONTON, O.—The Ironton Electric Ry., Light & Power Co. was incorporated in New Jersey March 7; capital stock, $300,000, with $1,000 paid in; incorporators, Lucius C. Ryce, of Plainfield, N. J.; Geo. L. Shearer, T. C. Press, of New York.

LIMA, O.—Press reports state that a scheme headed by Chicago capitalists is to build an electric road from this city to Bellefontaine, a distance of about 100 miles. The road could follow the right of way secured several years ago for the Columbus, Lima & Milwaukee R. R. All the grading and building of culverts have been done, and it would require but little repairing to make the bed ready. The road near Bellefontaine passes through a hilly section of country, but the opening has been cut through the rock and an electric line could be easily constructed. The grading for the Columbus road is also completed between this city and Defiance. Bridges and culverts have been in for several years, but the completion of the road has been delayed, and it is expected, should the Bellefontaine road be built, that it will be extended to Defiance and then in the other direction to Columbus.

YOUNGSTOWN, O.—An election will be held in April to vote on a proposition to issue $20,000 in bonds to aid in the construction of an electric railway from this city to Canfield, a distance of 10 miles.

DETROIT, MICH.—The Detroit Ry. Co. has been granted a franchise by the township board of Springwells.

CHICAGO, ILL.—A correspondent informs us that the contract for the pedestals, estimated to cost about $450,000, for the Northwestern Elevated R. R. will probably be awarded in a few days, and the contract for the track and stations later. The Union Bridge Co. and the Elmira Bridge Co. were awarded the contract for about 30,000 tons of structural steel, as noted in our issue of Feb. 21. Consult. Engr., J. A. L. Waddell, Keith & Perry Bldg., Kansas City, Mo.——It is reported that the power house of the Chicago & North Shore Electric Ry. Co. at Edgewater was destroyed by fire March 4, together with most of the cars and the dynamos; loss, $150,000.

MURPHYSBORO, ILL.—The Murphysboro St. Ry. Co. has been incorporated, with a capital stock of $11,000; incorporators, Thos. M. Logan, A. B. Winton and S. W. Ward.

SAVANNA, ILL.—The City St. Ry. Co. has been incorporated, with a capital stock of $25,000; incorporators, W. W. Cargill, James B. Canterbury and Edwin B. Magill.

VENICE, ILL.—Press reports state that the village board has granted Frank McCambridge, of Venice, and C. H. Sharman, of the Madison Ferry Co., a 20-year franchise to build an electric railway within the limits of the village and on Madison Ave., in Madison, to the southern limits of Granite City. The work is to commence within 60 days, and the road to be finished within six months after the acceptance of the franchise.

WAUKESHA, WIS.—Bids were received on March 7 for constructing a stone power house for the Beach Electric Ry. Co., which is to be completed by April 25. Engr., W. Powrie.

ST. LOUIS, MO.—The St. Louis County St. Ry. Co. has increased its capital stock from $20,000 to $50,000. Secy., J. B. Greensfelder, of Central, Mo.——The Southern Electric Ry. Co. has been granted permission by the county court at Clayton to extend its road from River des Peres to Jefferson Barracks, work on which will commence in a few days. Gen. Man., Jos. S. Minary.——The Lindell Ry. Co. has petitioned for permission to extend its Chouteau Ave. line from Forest Park to the city limits. Gen. Man., Geo. W. Baumhoff.

DENVER, COLO.—The plant of the Denver Consolidated Tramway Co., recently destroyed by an explosion of the boilers, will be rebuilt and enlarged at once, plans and specifications for which are being prepared. Constr. Engr., John A. Beeler, 84 Railroad Bldg.

ONTARIO, CAL.—It is reported that an electric railway company has been incorporated, with a capital stock of $100,000. F. B. Stamm, of Ontario; G. W. Foote, of Pomona, and John Jenkins, of Chicago, Ill., are interested.

ELECTRIC LIGHT AND POWER.

LOWELL, MASS.—E. Garfield Baker is considering a scheme for putting in an electric light plant at Hunt's Falls, at an estimated cost of $10,000.

ALBANY, N. Y.—The governor has signed the bill appropriating $16,000 for electric lighting, ventilating and for making other improvements at the armory.

ALLEGHENY, PA.—Westinghouse, Church, Kerr & Co. have been awarded a contract by the board of public works for one 250 and four 150-HP. engines for the new electric light plant, at $10,250.

PHILADELPHIA, PA.—Bids are asked until March 22 for materials for an electric light plant at Fort Delaware, as stated in our advertising columns. Second Lieut. Spencer Cosby, U. S. Engr. Office.

BALTIMORE, MD.—Bids are asked until March 22 for 2,500 4-lb. sand-mold circular shape zincs of Star Lehigh spelter, 1,500 battery coppers, Bishop's compound wire No. 14; 50 barrels bluestone, 200 cells Leclanche Gonda battery, complete; 500 battery jars, 250 telegraph poles, 500 4-pin cross arms, complete; 100 6-pin cross arms, complete; 50 T arms, 50 backboards, ½ mile Grimshaw wire, 100 lbs. office wire, 15 miles No. 12 copper wire, 2 miles of No. 10 K. K. copper line wire, 1,000 glass insulators, 200 McIntyre sleeves for No. 12 wire for the use of the police and fire alarm telegraph. J. A. Preston, Bd. Fire Comrs.

BALTIMORE, MD.—Press reports state that the Susquehanna River Electric Co., recently incorporated, has purchased the plant of the Susquehanna Water Power & Paper Co., near Conowingo. The plant carries with it about 1½ miles of water front on both sides of the river, between Conowingo and Octarora creeks. With this purchase the electric company now controls about 6½ miles of water front on the Susquehanna River, having a fall of 100 ft., and affording excellent power to generate electricity. The buildings of the Water Power & Paper Co. will be converted into an electric plant at once. All the present machinery will be taken out and the interior remodeled into a power house. The promoters of the electric company say they expect to have their plant in operation within a year.

LYNCHBURG, VA.—The council has voted to issue $60,000 in bonds for the erection of an electric light plant. Consult. Engr., David Evans, of Baltimore.

RICHMOND, VA.—The council is considering a resolution for constructing a municipal electric light plant, estimated to cost $150,000.

ATLANTA, GA.—The Atlanta Electric Power Co. has been organized, with a capital stock of $100,000 all paid in, with power to increase it to $2,000,000, to develop 14,500 HP. at a point on the Chattahoochee River seven miles from the city and 15,000 HP. at a point 13½ miles from the city. A dam 550 ft. in length will be built at the nearest of these places. The dam will be constructed of massive timber work, bedded in concrete. The power house will be of heavy masonry work, and its foundation extend above the highest water level, surmounted by a steel frame structure 325 ft. long, 50 ft. wide, and 42 ft. high, under the roof truss. This power house will accommodate 14 generating units. Each operating unit will consist of a double horizontal turbine wheel of 1,000 HP., connected direct to a 1,000 HP. electric generator. Jonathan H. Vail, 39 Cortlandt St., New York, has prepared the plans and is at the head of the company. The others interested are: E. A. Thornton, James D. Collins, and John A. Grant, of Atlanta; James Swann and Hugh R. Gardiner, of New York, and Richard N. King, of Dayton, O.

JACKSONVILLE, FLA.—Bids are asked until March 21 for furnishing 50,000 ½-in. copper-coated carbons. W. C. West, Recdr.

TAMPA, FLA.—The council is considering an ordinance for the construction of an electric light plant.

WATER VALLEY, MISS.—Bids are asked for a 1,200 to 1,500-light dynamo for the electric light plant, according to reports. G. D. Able, Mayor.

JACKSON, TENN.—The council has voted to construct an electric light plant in connection with the water-works.

MOUNT STERLING, KY.—The council has awarded the contract for the construction of an electric light plant to John T. Martin, of Xenia, O., who has purchased the old plant and the gas plant, and will at once construct a new electric light plant in connection with the new water-works, for which he has the contract.

VERSAILLES, KY.—The council has voted to hold an election to vote on the question of issuing $4,000 in bonds for building an electric light plant.

LONDON, O.—A proposition to issue $25,000 in bonds for an electric light plant will be voted upon at the coming election.

CARBON, IND.—The council has accepted the proposition of Fox Bros. to put in an electric light plant to cost between $4,000 and $5,000.

VINCENNES, IND.—The Vincennes Electric Light & Power Co. has increased its capital stock from $20,000 to $40,000.

CHESANING, MICH.—C. D. Chase, of Detroit, has been awarded the contract for an electric light plant.

FLUSHING, MICH.—It is reported that the citizens will vote on the question of putting in an electric light plant March 25.

GRAND RAPIDS, MICH.—Bids are asked until March 19 for the purchase of $150,000 in bonds for an electric light plant. W. A. Shinkman, Cy. Clk.

PORT HURON, MICH.—The council will submit to the voters at the coming election the question of issuing $30,000 in bonds for constructing an electric light plant. This proposition was defeated at an election in November.

UNION CITY, MICH.—It is reported that Rheubottom & Bond have been awarded a contract for constructing an electric light plant.

ROSSVILLE, ILL.—Frank L. Stewart has been granted a franchise for an electric light plant, and for a street railway.

GALESVILLE, WIS.—D. M. Benton & Co. have purchased a tract of land, on which will be erected an electric light plant, work on which will soon begin.

MINNEAPOLIS, MINN.—Press reports state that Thomas Lowry, Pres. Twin City Rapid Transit Co., and Charles A. Pillsbury, as officers, in conjunction with a number of Eastern capitalists, are considering a scheme to utilize the water power a short distance below St. Anthony Falls, to operate large power plants.

INDEPENDENCE, IA.—The citizens voted March 4 on the question of issuing bonds for an electric light plant.

HELENA, MONT.—Bids are asked until March 25 for lighting the public buildings of the city for one to five years. Stephen Carpenter, Cy. Clk.

SACRAMENTO, CAL.—The Sacramento Electric Light & Power Co. received bids on March 10 for constructing a superstructure for the plant at Folsom. Gen. Supt., T. A. W. Shock; Ch. Engr., H. T. Knight, Folsom.

STIRLING, ONT.—A company is being organized to put in an electric light plant and water-works.

TORONTO, ONT.—The aldermen are considering an ordinance for issuing $277,000 to $310,000 in bonds for an electric light plant.

PORTAGE LA PRAIRIE, MAN.—The citizens are considering a proposition for damming the Assiniboine River near this place to develop a water power of 1,200 to 1,500 HP., at an estimated cost of $32,000. Smith Curtiss, and Geo. H. Webster, Ch. Engr. Manatoba & North Western Ry., are interested.

NEW COMPANIES.—Merchants' Electric Light Co., East Liverpool, O.; $20,000.

Chicago Sidewalk Light Co., Chicago, Ill.; $5,000; to manufacture sidewalk lights; James Magnusen, Martin Magnusen.

Union Illuminating Co., Seattle, Wash.; $100,000; L. J. Coleman, Wm. F. Wickman, A. L. Hawley, C. A. Killbourne, P. P. Shaw.

Canajoharie Electric Light & Power Co., Canajoharie, N. Y.; $25,000; W. J. Arkell, Barttlet, Canajoharie; Austin L. McCrae, Gouverneur.

Citizens' Light, Heat & Power Co., Shenandoah, Pa.; $10,000, with $1,000 paid in; Treas., Joseph F. Lamorelle, 506 North 18th St., Philadelphia.

Oxley & Enos Mfg. Co., New York, N. Y.; to manufacture electric light fixtures, etc.; $1,500; Edward A. Stevenson, Brooklyn; Franklyn Paddock, New York.

BRIDGES.

BANGOR, ME.—The Bangor Bridge Co. is reported as intending to construct an iron bridge across the river.

BELFAST, ME.—The Berlin Iron Bridge Co. has prepared plans for a proposed bridge across Belfast Harbor at the foot of Main St. Local papers state that the plans call for cast iron piling, a 200-ft. section at the west end, a draw of 147 ft., and a 740-ft. section at the east end.

HOLYOKE, MASS.—The city engineer writes us that the contract for the bridge on Cabot St. has been awarded to Bosworth & Co., of Holyoke, at $22,240. The bridge will have three spans and be built of brick and stone.

PROVIDENCE, R. I.—Bids are asked until March 21 for removing the old bridges and constructing new stone and Cushing piers at the site of the Washington Row bridge over the Providence River. Robt. E. Smith, Comr. Pub. Wks.

BROOKLYN, N. Y.—The mayor has directed the corporation council to draft a bill authorizing the cities of Brooklyn and New York to construct a bridge over the East River at the place mentioned in the charter of the East River Bridge Co., of which Frederick Uhlman is president. The bridge would be built from the foot of Broadway, in the Eastern District, Brooklyn, to Grand St., New York.

ITHACA, N. Y.—At a special election March 9 the citizens voted in favor of building a bridge connecting East Hill with South Hill. James W. Reed, Engr., writes us that it will probably be necessary to secure special legislation before issuing the bonds, but that it is expected to build the bridge this summer.

ROCHESTER, N. Y.—The state senate has passed a bill appropriating $25,000 for a bridge over the Erie Canal at Exchange St.—The state engineer has submitted plans for a $75,000 bridge to replace the present structure at West Ave.

TROY, N. Y.—It is reported probable that a new bridge will be erected over the railway tracks at Johnston Ave.

PATERSON, N. J.—The house has passed a bill authorizing this city to issue $50,000 in bonds for a bridge across the Passaic River.

TRENTON, N. J.—The Pennsylvania R. R. Co. has offered to contribute $5,000 to the city or county toward the erection of an overhead bridge or a tunnel at Hermitage Ave.

PHILADELPHIA, PA.—Wiliam H. Brown Ch. Engr. Pennsylvania R. R. Co., writes us that bids for the superstructure of the Delaware River bridge were to be opened March 13.

PITTSBURG, PA.—Local papers state that a new bridge will be erected over the Allegheny River in place of the Sharpsburg and Lawrenceville bridge. Geo. A. Chanfant is interested.

WILLIAMSPORT, MD.—O. M. Williams, Mayor, is reported as receiving bids and specifications for the proposed bridge across the Potomac River, noted in our issue of last week.

RICHMOND, VA.—It is stated that a large bridge will be built in this city by a street railway company, in which W. F. Jenkins is interested.

JACKSONVILLE, FLA.—Efforts are being made to secure a bridge at the South Side. Geo. S. Ferry is interested.

NASHVILLE, TENN.—J. A. Jowett, Cy.Engr., writes us that the board of public works is holding over the bids for the College St. bridge, recently advertised in Engineering News, pending certain proposals made by the company that has the contract for constructing the Lick branch sewer.

CINCINNATI, O.—The city engineer is reported as making the following statement in regard to bridge work contemplated in this city: There will be quite a little. There is the Fern St. bridge for which the city will probably be ready for the advertising early in the summer. The Bold Face viaduct can be advertised at once, if no new trial is granted. The Kenton St. viaduct is ready for business, and condemnation proceedings is the next step to be taken. The Spring Grove Ave. bridge over Mill Creek will be built during the latter part of the summer. The Liberty St. bridge over the canal has been contracted for, and will be up in a month. The Fern St. bridge involves an estimated expenditure of $20,000; Spring Grove Ave. bridge, $40,000; Bold Face viaduct, $60,000; Kenton St. viaduct, $40,000, and the Liberty St. bridge, $2[illegible].

ADRIAN, MICH.—Residents of Ward 1 have petitioned for a bridge from the foot of Tecumseh St. across the railway track to Treat St.

BAY CITY, MICH.—The officers of the Union St. Railway Co. met in Saginaw March 2 and decided to secure plans for an iron and steel structure for rebuilding the Bristol St. bridge.

BUCHANAN, MICH.—A press report states that a new bridge will soon be built across the St. Joseph River at this place, the bridge to be 400 ft. in length and cost $14,000.

HILLSBORO, ILL.—The city council received nine bids for the construction of four steel bridges, but rejected them all.

IRVING, WIS.—The Wisconsin Central Ry. Co. is reported about to build a new bridge across the Chippewa River at this place.

BURLINGTON, IA.—The Burlington & Mississippi River Bridge Co. has submitted a proposition to the council to construct the proposed new bridge across the Mississippi River at this place, provided the city will levy a tax of 3% upon the taxable property of the city, payable in three years, 1% each year. Pres., Wm. H. Fitch; Secy., Geo. O. Ray.

ST. PAUL, MINN.—The contract for the substructure of the proposed Como Ave. bridge over the Great Northern Ry. tracks has been awarded to Chas. Stone, at $11,612.

PLATTSMOUTH, NEB.—The contract for constructing county bridges in 1895 has been awarded to J. R. Sheeley, of Lincoln, at $3.14 per lin. ft. The contract last year was at the rate of $3.80 per ft.

KANSAS CITY, MO.—Efforts are being made to secure the construction of a viaduct estimated to cost $100,000 to connect the Southwest bluff with the Bottoms. John Donnelly, ex-Cy. Engr., has submitted a plan.

GEORGETOWN, TEX.—The contract for constructing 11 steel bridges on the Trinity, Cameron & Western R. R. has been awarded to the Hopkins Construction Co., of St. Louis. Press reports state that these bridges are to be constructed according to Theodore Cooper specifications, class A, and that these are the only railway bridges in the state built on these specifications.

DENVER, COLO.—Bids are asked until March 23 for the construction of masonry abutments for the Broadway bridge. Ch. Engr., E. P. Martin, Arthur C. Harris, Pres. Bd. Pub. Wks.

PORTLAND, ORE.—Bids are asked until April 8 for the purchase of $200,000 of 30-year 5% bridge bonds. J. V. Beach, Clk. Bridge Com.

BUILDINGS.

PITTSFIELD, MASS.—The council is reported about to be petitioned by the school committee for an appropriation of $100,000 for the construction of two school buildings.

PROVIDENCE, R. I.—The city treasurer has been authorized to issue $400,000 in bonds for the construction of new school buildings.

NEW LONDON, CONN.—The Norwich & New York Transportation Co. is about to construct a new iron station, surveys for which have been made, according to reports.

ALBANY, N. Y.—Bids are asked until March 19 for improving the buildings of the water department headquarters at Quackenbush and Montgomery Sts. Arch., Edward Ogden & Son, 64 State St.; Geo. I. Bailey, Supt.

BUFFALO, N. Y.—Three new apartment houses are projected in the residence part of the city. T. H. Loverin has prepared plans for a 4-story brick structure, to be built for George Brownell and others, at the southeast corner of Georgia and Chippewa streets, to cost about $50,000. Rung Bros. have prepared plans for a 6-story brick structure, to be built on Glenwood Ave., at Cold Spring, for themselves. It will cost about $30,000. James R. Kimball has prepared plans for a 4-story brick structure costing $20,000, to be erected for Oscar L. Harries, on the south side of Bryant St., 200 ft. west of Ashland Ave.

BUFFALO, N. Y.—The following bids were received March 8 for the mason, stone and brick work on the new addition to the Erie county penitentiary, the bidders being all Buffalo men: William Schumacher, $9,755; C. A. Ruff, $10,777; Schmidt Bros., $12,130; Charles Berrick & Sons, $9,889; W. M. Savage, $13,400; Roberts, Lake & Linkerman, $19,477; Geo. W. Patridge, $11,131; Henry Schafer & Sons, $9,929; F. T. Reynolds, $10,500; Collingwood & Donaldson, $7,397; Geo. E. Frank & Bros., $10,382; B. I. Crooker, $13,152; Geo. W. Carter & Sons, $11,400; Watson & McGinnis, $8,200.—On cut stone there were separate bids as follows: R. & H. Fogelsonger, $1,499; Collingwood & Donaldson, $1,948; W. L. Savage & Co., $2,000; Queen City Cut Stone Co., $1,534; A. P. Kerr, $2,175; Brady & Malby, $2,024.—August Esenwein has completed plans for the buildings for the new Birge wallpaper plant. There will be three main buildings covering nearly three acres of ground, and separate engine and boiler houses. The buildings are to be but two stories high and of mill construction. They will cost about $50,000.

NEW YORK, N. Y.—Plans have been filed as follows: John J. Belden, of Syracuse, 10-story brick hotel, on 42d St. and Madison Ave., to cost $1,000,000; Boehm & Coon, 33 W. 89th St., 9-story brick store, to cost $300,000; Reformed Protestant Dutch Church, 11-story brick office building, at 37 and 39 Maiden Lane, to cost $150,000.

PLATTSBURG, N. Y.—Bids are asked until April 4 for the construction of hospital, building for fire apparatus and changing old barracks into quarters for band and non-commissioned officers, also plumbing, heating and gas-piping, at Plattsburg Barracks. Capt. Geo. E. Pond, A. Q. M., U. S. A.

TROY, N. Y.—Bids are asked until March 28 for the purchase of $120,000 of 3½% court house bonds. Geo. H. Morrison, Treas. Rensselaer County.

PATERSON, N. J.—The Passaic county board of freeholders is considering the construction of a new court house.

PITTSBURG, PA.—Bids are asked by the Westinghouse Machine Co. until March 30 for the erection of new shops.

WASHINGTON, D. C.—Bids are asked until April 10 for constructing an administration building and other buildings at Fort Meyer, Va. C. R. Barnett, Depot Q. M.

NORFOLK, VA.—J. P. Andre Mottu & Co., Tranby St., are prepared to receive plans for a five-story brick hotel, estimated to cost $150,000.

WILLIAMSON, W. VA.—Bids are asked until April 8 for the construction of the Mingo county jail. L. F. Drake, County Clk.

WILMINGTON, N. C.—Press reports state that the company owning the Union Cotton Mills, of Union, S. C., will soon begin the erection of another mill of about 2,000 spindles and 300 looms capacity. The undertaking started at Raleigh, N. C., to build a fourth cotton factory has been practically abandoned, for the present at least, as the encouragement expected has not been extended. The gingham mills at Charlotte, N. C., known as the Highland Park Mfg. Co., which recently announced the intention of making its own yarns, will begin the erection of an addition to cost $100,000, and will put in machinery for spinning yarns.

CLEVELAND, O.—A committee is taking steps to secure an architect for the new chamber of commerce building.

DETROIT, MICH.—The board of supervisors has decided to again submit the proposition to issue $1,500,000 in bonds for a new county building to the voters at the spring election.

DETROIT, MICH.—Bids are asked until March 21 for the construction of light stations for Hay Lake Channel, St. Mary's River, Mich. Maj. M. B. Adams, U. S. Engr. Office.

LANSING, MICH.—Bids are asked until March 20 for the construction of the proposed $100,000 city hall. E. O. Sellers, Supt. Pub. Wks.

RICHMOND, IND.—A correspondent writes us that the Nicholson Mfg. Co. will soon construct a large building for its printing and book binding establishment, and that John M. Gaar will build a large apartment house.

BETHALTO, ILL.—It is reported that the Kaufman mill and a large elevator adjoining were destroyed by fire March 2; loss, $200,000.

ST. PAUL, MINN.—The state capitol commissioners will readvertise for plans for the new structure as soon as the bill has been signed by the governor, according to reports.

OMAHA, NEB.—Bids are asked until April 1 for constructing a barrack wing, a building for officers' quarters, etc. Maj. Chas. F. Humphrey, U. S. A.

KANSAS CITY, MO.—Plans have been submitted to the board of education for the new two-story library building, estimated to cost $200,000. The building will be of stone, 253 × 139 ft., and 45 ft. high. Arch., Wm. F. Hackney; Consult. Arch., Adriance Van Brunt.

WATER-WORKS.

AUBURN, ME.—F. E. Bisbee, Supt., writes us that $6,000 will be spent this summer in extensions, the money having been already appropriated for the work.

NASHUA, N. H.—The Pennichuck Water Co. is reported about to lay a new main in Main St., at a cost of $15,000, and to make other improvements.

BURLINGTON, VT.—The water commissioner has been authorized to purchase $3,000 worth of pipe.

BOSTON, MASS.—Bids are asked by the water board until March 18 for eight 36-in., four 30-in. and seven 20-in. stop-cocks.

HINGHAM, MASS.—A committee of five has been appointed to consider the question of buying the works or constructing a new system. Charles W. Marsh is town clerk.

HYDE PARK, MASS.—The special committee has recommended that a town meeting be held to take steps to purchase the works.

MALDEN, MASS.—John N. Jordan, Supt., writes us that the city will probably lay 10,000 ft. of extensions and will need 18 hydrants, 40 gates and 500 meters. George A. Wetherbee, Cy. Engr.

NEW BEDFORD, MASS.—The water board is negotiating for the location of a new reservoir in the town of Dartmouth.

READING, MASS.—The town has voted to authorize the water commissioners to carry out the recommendation of the state board of health in regard to filtering and purifying the water. It is stated that $12,000 will be spent, including $6,000 for a filter.

SPRINGFIELD, MASS.—J. C. Hancock, Supt., writes us that the only work to be done this summer will be the laying of 3½ or 4 miles of distribution pipe.

WALPOLE, MASS.—George P. Morey, Town Clk., writes us that nothing will be done in regard to the proposed works until the ground is settled in the spring; no engineer yet employed; population, 2,700.

WALTHAM, MASS.—The aldermen are considering an appropriation of $10,000 for extensions of the works.

WAREHAM, MASS.—J. K. Nye, E. D. Eldredge and H. H. Hathaway have petitioned for a charter for the Wareham Water Co.; capital stock, $50,000.

SEYMOUR, MASS.—The citizens are reported much in favor of granting a franchise to the water company noted last week. C. French is interested.

NEW HAVEN, CONN.—The New Haven Water Co. has contracted with Henry R. Worthington for a 10,000,000-gallon horizontal high-duty pumping engine, and is making extensive improvements in its plant.

ALBANY, N. Y.—The council has voted to issue $140,000 in bonds, as follows: For the construction of foundation for second pump, $15,000; to erect second pump, $12,000; to close contracts with E. P. Allis Co. for pumps, $48,000; placing of new boilers, $10,000; changes to boiler and engine room, $4,500; proposed new water mains and appurtenances, $30,000; contingencies, $5,500; for the construction of foundation for third pump and for erection of building for same, $15,000.

BROCTON, N. Y.—The question of constructing a gravity system of works, estimated to cost about $20,000, is again being agitated.

CANANDAIGUA, N. Y.—We are informed that the contract for the complete construction of works has been awarded to Wm. T. O'Connor & Co., of Syracuse, at $124,738, who have purchased materials as follows: Ludlow Valve Mfg. Co., hydrants, valves and boxes, $5,900; Gould Mfg. Co., of Seneca Falls, pumps, boilers and engines, $9,125; Buffalo Cast Iron Pipe Co., pipe and specials, $49,000; General Electric Co., electric plant, $8,650. The contract for gate boxes has been sub-let to the Robinson Chilled Plow Co., of Canandaigua.

CLYDE, N. Y.—The village trustees have contracted with the Clyde Water Supply Co. for a supply for five years, at $2,000 a year. It is stated that the company will be required to furnish 18 additional hydrants, and put in a new pump and a new filter.

CORNING, N. Y.—H. C. Heermans, Cy. Engr., writes us that the proposition to issue $70,000 in bonds for the proposed extensions and improvements was defeated March 5.

FLUSHING, N. Y.—The water committee has been directed to secure plans and a site for a stand-pipe; trustees will consider the question at the regular April meeting.

LANCASTER, N. Y.—The water-works question was defeated March 2 by 22 votes, but it is stated that the question will doubtless be voted upon again soon.

MIDDLEVILLE, N. Y.—A public meeting was held last week to consider the question of works.

ONEIDA, N. Y.—It is stated that the question of purchasing the works will be voted upon at a charter election April 2. O. S. Smith, Clk. Bd.

RAVENA, N. Y.—A franchise has been granted John A. Longyear, C. E., E. B. Walker, J. A. Gaul, and others, of Kingston, N. Y., to put in works in this village and Coeymans, and we are informed that surveys will be commenced as soon as the weather permits. Water supply will be by gravity from a creek, with storage dams.

SCHENECTADY, N. Y.—Our correspondent writes us that the bill providing for an issue of $215,000 in bonds for a new water supply system has been twice approved by the common council, as required by the new constitution, and now awaits its final passage by the legislature, which will probably soon occur.

TUCKAHOE, N. Y.—A correspondent writes us as follows: A water company was recently organized, principally by resident owners of property, for the purpose of supplying the village with water and a fire protection through 50 hydrants, with pumping station, stand-pipe, etc. Petition was presented to the town board Feb. 5, at a regular meeting (Tuckahoe being unincorporated) and a committee was appointed with purpose of investigation of the rights and power of the board in the premises. Meetings of the board were held on each succeeding Tuesday, and on March 5 committee held meeting behind locked doors, prepared resolution authorizing contract to be made with the Westchester Water-Works Co., which resolution was railroaded through at once upon the organization of the board a few minutes after the close of the committee meeting, without any consideration of the claims of the local company, or its petition, signed by a majority of the property owners of the proposed district, asking that contract be made with the local company. The contract authorized with the Westchester company provides hydrant rental at $40 each for as many hydrants as may be permitted with a tax of 3 mills per dollar of assessed valuation. This being now about $160,000, will permit but 12 hydrants to be set, instead of 50, as proposed by the local company. The action of the board in this matter has been severely criticised, and definite action on the part of the local company, backed with public opinion, may follow. Further information can be obtained from C. W. Dutcher, one of the incorporators, 150 Fifth Ave., New York, or F. S. Pecke, Engr., Flushing.

ATLANTIC CITY, N. J.—A water company is reported about to adopt the meter system.

CLAYTON, N. J.—The American Pipe Mfg. Co., of Philadelphia, is reported about to commence the construction of works to supply this place and Pitman Grove.

HOBOKEN, N. J.—The house has passed a bill authorizing this city to issue $500,000 in bonds for new works.

JERSEY CITY, N. J.—Bids are asked until March 25 for a new water supply. George T. Bouton, Clk. Comrs.

PATERSON, N. J.—The question of constructing works will be voted upon at the coming spring election. The committee has recommended that an artesian supply of 8,000,000 gallons daily be secured, at an estimated cost of $782,500.

BRADFORD, PA.—S. D. Heffner, Supt., writes us that $15,000 will be spent this summer, mostly in replacing old pipe that is too small or rusted. The work will be advertised in May or June.

EASTON, PA.—A committee has been appointed to go to Harrisburg to protest against the bill which requires towns wishing to construct new works first to purchase the existing plant.

HELLERTOWN, PA.—The question of constructing works is being agitated.

MANOR, PA.—W. F. Brinker, Town Clk., writes us that the village intends to contract with the Westmoreland Water Co. for fire plugs for fire protection and will need hose and other fire equipment.

MARYSVILLE, PA.—The council has granted a franchise and contracted for 20 fire plugs at $400 a year, the construction of the works to be commenced within 18 months and completed within 24 months.

McKEESPORT, PA.—The council has voted to have a chemical examination and test made of the Monongahela River water, with a view to making surveys and estimates for securing a supply from this source.

SELLERSVILLE, PA.—Warren Cressman, Engr., and Prof. H. T. Williams are members of committees appointed to investigate the question of works for this place.

MOUNT POCONO, PA.—The Mount Pocono Water Co. has been incorporated with a capital stock of $4,000 to supply this village with water. Treas., Edward D. Hooker.

COLLEGE STATION, MD.—The trustees of the Maryland Agricultural College are considering plans for securing an additional water supply, the present artesian supply being inadequate.

HYATTSVILLE, MD.—Justice Carr is a member of a committee appointed by the Citizens' Improvement Association to investigate the question of works, which it is thought can be put in for $15,000. F. A. Holden, Secy. Ass'n.

NORFOLK, VA.—The council has made a new contract with the National Artesian Well Co. (formerly the Ray Artesian Well Co.) to secure a supply of artesian water. The company offers to sink a well 2,000 ft. deep for $10,000, which sum is to be applied to the contract price of $65,000 for securing water, if the effort is successful.

RICHMOND, VA.—It is stated that new machinery will be purchased and extensive improvements made. C. E. Bolling, Supt.

CEREDO, W. VA.—The city wishes to grant a franchise. C. F. Millender, Secy. Com.

WAYCROSS, GA.—H. Murphy, Chn. Com., writes us that bids will be opened about April 1 for a 1,000,000-gallon pump.

CLINTON, KY.—J. D. Taylor writes us that all of the bids for constructing the water-works were rejected, and that the mayor will probably advertise soon for new bids.

GREENVILLE, KY.—W. H. Wilkinson, Cy. Clk., writes us that no steps have yet been taken by the committee in regard to works, but that something will probably be done this year; population, 1,000.

MOUNT STERLING, KY.—The Mount Sterling Water-Works Co. is reported to have contracted with John P. Martin, of Xenia, O., for the immediate construction of works.

BARNESVILLE, O.—H. E. Dement, Cy. Clk., writes us that he has received a large number of replies from different parts of the country, and a flood of correspondence from manufacturers of water-works materials, in response to the recent notice in Engineering News. The citizens are opposed to any increase in taxation at present, and it is impossible to tell what will be done in regard to securing works.

BUCYRUS, O.—The council is reported as struggling over a new contract with the water company, and it is stated that the coming election for councilmen will be decided on the issue of municipal ownership of the works.

CELINA, O.—Bids are asked by the village trustees until April 4 for the construction of works. Engrs., Voorhees & Witmer, Buffalo, N. Y.

ELMWOOD PLACE, O.—Cincinnati papers state that the question of water-works and electric lights is again being agitated in this village.

WELLSVILLE, O.—John W. Quinn, Supt., writes us that the contract for the work recently advertised has been awarded to S. G. Hallock, Wheeling, W. Va., for material and labor complete. The other bidders were as follows: Chandley Bros. & Co., Beaver Falls, Pa.; John H. Synon & Co., Chicago; P. Morley, East Liverpool, O.; W. M. Wooster, Wellsville, O.; W. M. Chisholm, East Liverpool, O.; A. P. Dennis, Wellsville; W. M. King, Wellsville, and Henry Nass, Wellsville.

WELLINGTON, O.—The citizens recently voted to issue $35,000 in bonds for works, but it has been found that this will not be sufficient, and an additional appropriation of $15,000 will be voted upon next month. It is probable that the whole project will be defeated.

YELLOW SPRINGS, O.—A committee has been appointed to receive bids for the construction of works, according to a press report.

VEVAY, IND.—A. H. Kennedy, Man. Rockport Water-Works Co., writes us that the contract for works at this place has been awarded to Guild & White, of Chattanooga, Tenn. at $15,500, the materials selected being as follows: Brownell & Co. boiler and heater, Deane duplex pump, Anniston pipe and specials, hydrants and valves manufactured by the Bourbon Copper & Brass Works.

HILLSBORO, ILL.—F. P. Winchester, Cy. Clk., writes us that it is not probable that definite steps will be taken in regard to building a new reservoir until after the new council is elected April 16.

CHESANING, MICH.—The contract for constructing works has been awarded to T. C. Brooks, of Jackson; engine and boiler to H. H. Humphrey, of Detroit, and that for the electric light plant to C. B. Chase, of Detroit.

DETROIT, MICH.—The commissioners have sold $100,000 in bonds for a 48-in. main from the works to the city.

FLUSHING, MICH.—A special election will be held March 5 to vote on an appropriation of $20,000 for works and an electric light plant.

JACKSON, MICH.—The board of public works has again recommended the adoption of the meter system.

YPSILANTI, MICH.—H. Batchelder, Deputy Cy. Clk., writes us that bids are being received for a new pump, bids to be opened about April 1. H. M. Curtis, Chn. Bd. Pub. Wks.

ABINGDON, ILL.—The citizens are reported as agitating the question of constructing works.

BELLEVILLE, ILL.—The Deep Well Water Co. which recently secured a franchise from the city council, is reported as locating 140 fire hydrants.

ELGIN, ILL.—R. R. Jarkin, Supt., writes us that a contract for a 6,000,000-gallon pump has been awarded to the Holly Mfg. Co., and that the city will soon purchase some 8 and 6-in. cast iron pipe.

LACON, ILL.—It is reported that another artesian well will soon be sunk.

NEENAH, WIS.—S. J. Chaefant writes us that the city is contemplating putting in either a system of filters or driven wells; meters will also be put in. The city will also probably purchase five or six carloads of 5 and 6-in. pipe.

SPARTA, WIS.—Bids are asked until March 18 for furnishing material and constructing works, including about 30,000 ft. of 10 to 4-in. pipe, 35 hydrants, wood tank on 70-ft. brick tower and two pumping engines. Howard Teasdale, Cy. Clk.

CASEY, IA.—The proposition to issue $3,500 in bonds for water-works has been defeated by a vote of 117 to 76.

ABILENE, KAN.—The works were purchased March 8 by the bondholders' committee for $20,000. The plant is bonded for $150,000.

SPRINGFIELD, NEB.—An election will be held April 2 to vote on an issue of $5,000 in bonds for works.

SHERIDAN, WYO.—It is stated that construction will soon be resumed on the new works. The reservoir and about 7 miles of mains were completed last fall.

ST. JOSEPH, MO.—The American Water-Works & Guarantee Co., of Pittsburg, owners of the works, has ratified the arrangement made by L. C. Burnes, Supt., with the city council for the extension and improvement of the works.

ST. LOUIS, MO.—The board of public improvements has adopted a resolution appropriating $33,000 for pipe, valves, etc.

PRINCETON, MO.—The citizens have voted to issue $20,000 in bonds for water-works and for macadamizing the streets.

SARCOXIE, MO.—The citizens are reported as discussing the question of works.

FLATONIA, TEX.—Efforts are being made to organize a company to put in works.

GAINESVILLE, TEX.—An artesian well has been sunk to a depth of 900 ft., and it is stated that the contractors will go 2,000 ft. if flowing water is not reached at a less depth.

SULPHUR SPRINGS, TEX.—The contract for constructing works is reported to have been awarded to a Dallas firm, construction to be commenced March 16 and the plant to be completed in 90 days.

NORMAN, OKLA.—Bids are asked for a supply of 4-in. cast iron and wrought iron pipe, hydrants, etc., according to reports. J. A. Jones, Chn. Com.

SEATTLE, WASH.—The city engineer has recommended that the city take steps to secure a gravity supply from Cedar River, at an estimated cost of $1,250,000. Unless this is done a new pumping engine will be needed at once.

VENTURA, CAL.—A committee has been appointed to investigate the question of works.

ARNPRIOR, ONT. Geo. E. Neilson, Town Clk., writes us that the council is considering the granting of a franchise, but that present appearances do not indicate that anything definite will be arrived at this year.

AYLMER, ONT.—W. J. Poupore has submitted estimates for additional work to cost $22,000, making $57,000 in all.

BROCKVILLE, ONT.—Bids are asked until March 18 for the purchase of $16,000 in 30-year 4½% water bonds. John Stagg, Chn. Com.

NIAGARA FALLS, ONT.—Surveys are being made for a site for the proposed new reservoir.

STIRLING, ONT.—A company has been organized to put in works; supply from springs 2½ miles distant.

IRRIGATION.

COZAD, NEB.—Press reports state that at a mass meeting of citizens March 1 it was decided to issue a call for an election for the purpose of voting $10,000 in bonds, to be given to the Cozad Irrigation Co., on condition that it completes the ditch and laterals by May 15. Petitions are being circulated, and the indications are that the plan will be a success. The company will commence work in full force next week.

AZUSA, CAL.—Bids were received March 9 for the purchase of $60,000 of first mortgage bonds of the Azusa Irrigation Co. This is part of an issue of $80,000 in bonds, which were issued to complete the system of irrigation works. A. P. Griffith, Fiscal Agent.

NEW COMPANIES.—West Side Canal Co., San Francisco, Cal.; $5,000,000, with $25,000 paid in; to construct irrigation ditches in Kings, Merced, Fresno, and Stanislaus counties; William Strader, H. W. Gray, T. L. Orr, A. B. Dobbins.

Ute Reservation Ditch Co., Durango, Colo.; $100,000; James J. Schutte, O. G. Galbreath, E. B. Morgan, J. C. Sullivan, T. F. Burgess.

Poplar Irrigation Co., Poplar, Cal.; $41,000, with $12,500 paid in; Jacob Hays, E. A. May, T. J. Hornsby, R. H. Clack, E. H. Dale, Poplar.

Anawashpa Irrigation & Power Co., Seattle, Wash.; $300,000; D. H. Longstaff, J. W. O'Keefe, B. L. Rathbun, B. K. Beecham, T. W. Butler.

Pannell Valley Irrigation Co., Garden City, Kan.; $30,000; to construct irrigation ditches at Garfield; R. J. Churchhill, J. Chapel, Frank Rose, Wm. Moore, John Wilkinson, Foster Rose.

South Side Irrigation Co., France School House, Dawson county, Neb.; $50,000; to construct irrigation ditches in Lincoln and Dawson counties; W. E. Young, J. W. Hiles, W. R. Potter, H. W. Davis, I. Beyett.

SEWERAGE.

MANCHESTER, N. H.—The council has adopted resolutions appropriating $75,000 for sewer construction.

BOSTON, MASS.—Bids are asked until March 16 for furnishing brick for use on the intercepting sewer in Dorchester. Wm. Jackson, Cy. Engr.——The corporation council has prepared a bill for the consideration of the committee for a system of sewage disposal for the Neponset Valley, including Dedham, Hyde Park, Milton, Quincy, and the southern section of this city. The sewer is to connect with the metropolitan system at Dorchester, and is estimated to cost $500,000.

BROOKLINE, MASS.—The selectmen are considering the question of draining the Chestnut St. district.

LYNN, MASS.—It is reported that Chas. W. Gay, Cy. Engr., will, in his annual report, recommend the construction of an impounding reservoir or purifying basin, the location for which was secured some time ago, instead of extending the outfall sewer at present, upon which $19,657 has been expended. The total cost of the system to date is $1,092,262.

WINCHESTER, MASS.—The town has voted to appropriate $50,000 for sewer construction.

PAWTUCKET, R. I.—It is reported that work will soon begin on the construction of a sewer which will cost about $50,000.

PROVIDENCE, R. I.—Bids are asked until March 19 for constructing about 7,465 ft. of 12 to 8-in. pipe sewers and 660 ft. of 18 and 16-in. brick sewers. Robt. E. Smith, Comr. Pub. Wks.

ALBANY, N. Y.—The council is considering the question of extending the Beaver Creek sewer, at an estimated cost of $80,000 to $100,000.

BUFFALO, N. Y.—The committee has decided to report favorably on the proposition to construct a sewer in Broadway, to readvertise for bids for constructing a sewer in Montana St., and to direct the engineer to prepare plans for a sewer in South Buffalo.

NEW YORK, N. Y.—Bids are asked by the commissioner of street improvements, 2622 Third Ave., until March 20, for constructing sewers in five streets.

ROCHESTER, N. Y.—It is reported that contracts will soon be awarded for constructing pipe sewers in eight streets, estimated to cost $70,000.

HACKENSACK, N. J.—The Hackensack improvement commission has been discussing plans for converting Hackensack Creek into a sewer.

MONTCLAIR, N. J.—The committee has recommended an appropriation of $60,000 for completing the main sewers.

SOUTH ORANGE, N. J.—Bids are asked by the village trustees until April 15 for the purchase of $25,000 in 5% sewer bonds.

ROSELLE, N. J.—Bids are asked until March 29 for the construction of about three miles of 15 to 10-in. pipe sewers, as stated in our advertising columns. Consult. Engr., Carrol Ph. Bassett, Summit, N. J.; G. A. Rawlins, Borough Clk.

BEAVER FALLS, PA.—The construction of a system, and that bonds will soon be issued and bids

LANSDALE, PA.—It is reported that engineers have been engaged to make a survey for a system. A. C. Godshall, Village Pres.

PITTSBURG, PA.—The committee on public works has recommended the construction of sewers in 20 streets.

READING, PA.—The committee has recommended appropriation as follows: Sewage disposal plant, pipe lines, etc., to cost $100,000; sewers in nine streets and completion of house sewers, to cost $42,000, and completion of pumping station, etc., to cost $27,000.

WILKINSBURG, PA.—S. A. Taylor, Engr., of this city, is interested in certain sewer and street work for which it is expected that contracts will soon be awarded.

WILLIAMSPORT, PA.—Geo. D. Snyder, Cy. Engr., writes us that the council has issued $100,000 in bonds for constructing sewers, and that contracts for the first part of the work will be awarded in about a month.

WILMINGTON, DEL.—It is reported that the Wilmington Sewerage Co. has petitioned the council for authority to construct a sewer in four streets. Pres., W. P. Toon.

WASHINGTON, D. C.—The district commissioners have ordered the construction of sewers in two streets.

MANCHESTER, VA.—It is reported that the committee is about to make a report on a proposed system, and that bonds will soon be issued and bids asked for constructing a system, estimated to cost about $75,000.

PETERSBURG, VA.—Bids are asked until March 20 for the construction of 4,650 ft. of 18 to 8-in. pipe sewers. John W. Hays, Cy. Engr.

AUGUSTA, GA.—The council has passed three ordinances for constructing sewers.

LOUISVILLE, KY.—Bids are asked by the board of public works until March 20 for constructing sewers in 15 streets.

PADUCAH, KY.—It is reported that the committee will recommend the construction of a system at once.

CLEVELAND, O.—The council has received the following bids for the construction of two sewers:

	Marcelline Ave.	Willson Ave.
James Connelly	$12,964	$29,520
John Mahon	14,871	.....
McCarthy & Sager	14,632	30,623
William Eggers	14,742	31,731
F. W. Dennart	15,897	32,327
Kuentz & Kuentz	14,673	39,495
Charles & Dan McCarthy	16,401	.....
Burgess & Gribben	16,437	40,882
Campbell Bros.	17,272	32,047
McCracken & McDowell	16,968	.....
Kirkham & Wells	16,652	.....
R. P. Burnett	16,419	35,540
Ford P. Beers	16,720	33,257
A. F. Helm	16,528	35,121
W. J. Gawne	17,340	37,228
Petry & Kuentz	16,922	.....
Clements Bros. Const'n Co.	17,850	33,093
William Stephen	18,974	Inf'm'l
A. G. Hausmann	17,248	.....
John Garry (informal)	.....	29,598

SANDUSKY, O.—Bids are asked until March 30 for constructing a sewer in one street. A. W. Miller, Cy. Clk.

ELWOOD, IND.—It is reported that a tract of swamp land, valued at $250,000, in this city, is to be drained by the construction of a sewer.

ALTON, ILL.—Plans for a system have been prepared by H. R. Stanford.

CHAMPAIGN, ILL.—Bids are asked until April 8 for constructing 27 miles of sewers, as stated in our advertising columns. J. P. Dunlap, Cy. Engr.

REDWOOD FALLS, MINN.—It is reported that the council has ordered the construction of sewers in two streets, work on which will probably soon be commenced.

JEFFERSON CITY, MO.—Bids are asked until April 1 for furnishing material and constructing a main sewer, as stated in our advertising columns. E. F. C. Harding, Engr.; A. P. Grimshaw, Mayor.

WINNIPEG, MAN.—The council has voted to construct sewers in two streets. C. J. Brown, Cy. Clk.

GARBAGE DISPOSAL.

NEWPORT, R. I.—The street committee has awarded the contract for the removal of coal ashes, dirt, etc., from March 1, 1895, to Dec. 31, 1897, to Thos. Pierce, at $235 per month. There were 18 bidders.

BRIDGEPORT, CONN.—The contract for the removal of garbage has been awarded to H. A. Whiting, at $7,500. The bids were published last week.

ROCHESTER, N. Y.—The board of health has approved the location of the Rochester Garbage Reduction Co.'s plant at Waynesport, and the plant will be constructed at that place at once.

ATLANTIC CITY, N. J.—The board of health is reported as corresponding with parties in regard to the cremation of the garbage of the city.

PITTSBURG, PA.—The contract for the collection and disposal of garbage for four years has been awarded to Chas. E. Flinn, at $79,700 a year. All the garbage will be burned and the construction of a garbage furnace will be commenced as soon as possible.

WHEELING, W. VA.—The "Intelligencer" states that the crematory shed was blown down last week and that it is nearly time that a new crematory, furnace, building and all, was built in a better location.

OAKLAND, CAL.—The question of garbage disposal is being considered by the council. It is stated that one councilman has a scheme for dumping it into scows and towing it out to sea.

STREETS AND ROADS.

HOLYOKE, MASS.—Bids are asked until March 19 for furnishing the city with 10,000 to 15,000 lin. ft. of granite curbing. John Wall, Chn. Com.

TAUNTON, MASS.—The aldermen have adopted a resolution appropriating $15,000 for paving and macadamizing and $15,000 for sidewalks.

ALBANY, N. Y.—The committee is considering the paving of North Pearl St. with granite blocks.

ALFRED, N. Y.—At an election March 5 the citizens voted to issue $8,000 in bonds for a macadamized road from Alfred Center to Alfred Station, a distance of two miles.

BROOKLYN, N. Y.—The mayor has directed the corporation counsel to prepare a bill for the legislature providing for the repaving of Atlantic Ave., at a cost of $100,000.

BUFFALO, N. Y.—The German Rock Asphalt & Cement Co. has been awarded a contract for paving with Trinidad Lake asphalt, at $11,522.

NEW YORK, N. Y.—Bids are asked by the department of public parks until March 20 for furnishing and delivering 10,000 cu. yds. of screened gravel at Central and Riverside parks, and until the same date by the commissioner of street improvements, 2622 3d Ave., for a supply of broken stone.——Residents north of the Harlem River have petitioned the mayor to approve the plan for a boulevard 182 ft. wide from 161st St. and Mott Ave. to Mosholu Parkway, a distance of 4½ miles. The work is estimated to cost from $12,000,000 to $30,000,000.

PATCHOGUE, N. Y.—There is talk of issuing $40,000 in bonds to macadamize about three miles of Ocean Ave. and Main St.

ROCHESTER, N. Y.—It is stated that considerable paving is contemplated.

UTICA, N. Y.—The council has voted to pave four streets. J. A. Cantwell, Cy. Clk.

JERSEY CITY, N. J.—Bids are asked until March 25 for paving 3,350 sq. yds. with asphalt on 4 ins. of concrete. Geo. T. Bouton, Clk. Comrs.

NEWARK, N. J.—Bids are asked until March 22 for paving Pompton turnpike in Verona township with telford pavement. Thos. McGowan, Dir. Freeholders.

TURTLE CREEK, PA.—The bids for paving Braddock and Penn Aves. were all rejected as too high.

WILKINSBURG, PA.—S. A. Taylor, Engr., of this city, is interested in projected street and sewer work for which it is stated that contracts will soon be awarded.

LOUISVILLE, KY.—J. Henry Hoertz, Secy. Bd. Pub. Wks., writes us that contracts for lime and cement were awarded to the Utica Lime Co. at 75 cts. per bbl., and for sewer pipe to Pat Bannon Co. Contracts for paving several alleys with one course of vitrified brick have been awarded at $17.50.

CINCINNATI, O.—The board of administration has voted to pave a large number of alleys with brick.

CLEVELAND, O.—Bids are asked by the park commissioners until March 20 for grading and improving Doan Brook parkway.——S. J. Baker, County Engr., has prepared plans for a boulevard 100 ft. wide from Collamer to Euclid Creek.

SANDUSKY, O.—A. W. Miller, Cy. Clk., informs us that bids were received for paving Water St. with 25 varieties of brick and blocks, the bids for Hallwood repressed block being as follows:

A. G. Pugh & Co.	$31,070
W. M. Graham & Co.	29,998
Coleman & Hallwood (Straitsville)	25,657
" " " (Townsend)	25,857
" " " (Jones)	29,457
" " " (Harris)	29,457
" " " (Bolans)	29,457
Groch & Peter (Athens)	28,469
W. A. Cain (Athens)	30,998
W. A. Cain (Nelsonville)	31,398
James McCloud	30,784

ZANESVILLE, O.—Bids are asked by the city clerk until March 25 for paving several streets with brick, according to reports.

FRANKFORT, IND.—The council has directed A. J. Hammond, Cy. Engr., to prepare plans and specifications for about 3,100 lin. ft. of brick paving on concrete foundation, about 21,600 sq. yds.

INDIANAPOLIS, IND.—The board of public works has ordered plans prepared for paving New Jersey St. from Home Ave. to 7th St., 1,600×30 ft., and Fort Wayne Ave., one section, 1,000 × 30 ft., and the other section, 1,000×50 ft., with asphalt. About 2,000 ft. of cement walks have been ordered on Washington St.

INDIANAPOLIS, IND.—Bids are asked until March 23 for paving with brick South Pennsylvania St., from Maryland to South; length, 1,380 ft.; width, 60 ft.; 9,329 sq. yds.; 6-in. concrete foundation and brick surface; 2,625 ft. 5×24-in. curb, 75 ft. rounded corner curb, 396 ft. marginal stone, two catch basins and eight inlets, with connecting pipe. Chas. C. Brown, Cy. Engr.

RICHMOND, IND.—Bids are asked until March 29

for 500 lin. ft. of stone crubing, 2,100 lin. ft. of grading and guttering, also for furnishing and setting five flush tanks and constructing 600 ft. of pipe sewer. H. L. Weber, Cy. Engr.

BLOOMINGTON, ILL.—The contract for paving North Main St. has been awarded to John Cherry, Jr.

WAUKEGAN, ILL.—Bids are asked until April 2 for 15,300 sq. yds. of brick paving, etc., as stated in our advertising columns. Henry Thacker, Cy. Clk.—H. W. Large, Engr., writes us that plans have been completed for paving six blocks in the business portion of the city, in addition to the work now advertised; brick paving upon a foundation of 6 ins. of macadam and 2 ins. gravel, and estimated to cost $22,765.

GLENCOE, ILL.—Bids are asked until March 26 for macadamizing 6,125 lin. ft. of Sheridan road, including a 90-ft. bridge, as stated in our advertising columns. The total bids received last mionth for this work, were published in our issue of Feb. 14. Engr., W. S. Shields, Chicago. Granville D. Hall, Village Clk.

PEORIA, ILL.—Bids are asked until April 4 for about 25,000 sq. yds. of brick paving, as stated in our advertising columns. Isaac Taylor, Comr. Pub. Wks.

ST. PAUL, MINN.—Bids are asked until March 18 for paving 6th St. with asphalt on a concrete foundation. John C. Mueller, Clk. Bd. Pub. Wks.

PRINCETON, MO.—The citizens are reported to have voted to issue bonds to macadamize the streets of this place.

HOUSTON, TEX—Bids are asked by the mayor until March 30 for the construction of sidewalks in several streets.

TRINIDAD, COLO.—Residents of this city and Catskill are considering plans for building a new wagon road to La Belle, a new mining camp, that will shorten the distance about ten miles.

SEATTLE, WASH.—The following bids were received for paving Pike St. with brick: T. W. Prosch & Co., $28,640; J. W. Fitts, $22,452; James Spurr & Co., with Denny brick, $21,936; with Seattle Brick & Tile Co.'s brick, $19,916; Stirratt & Getz, with Denny brick, $23,743; with Seattle Brick & Tile Co.'s brick, $21,049.

MISCELLANEOUS CONTRACTS AND SUPPLIES.

DRAINAGE BONDS.—Vincennes, Ind.—This county has sold $90,000 in bonds for drainage purposes.

COAL CARS.—New York, N. Y.—The Delaware, Lackawanna & Western R. R. Co. is reported as receiving bids for 500 coal cars.

Wicomico and Manokin rivers, and Cambridge Harbor, Md., and Nanticoke River, Del. Wm. F. Smith, U. S. Agent.

MASONRY FOUNDATIONS.—Providence, R. I.—The New York, New Haven & Hartford R. R. Co. has awarded the contract for 4,000 cu. yds. of granite masonry foundation for the new passenger station to J. T. Tank, at about $30,000.

REMOVAL OF WRECK.—Philadelphia, Pa.—Bids are asked until March 23 for removal of wreck of steamship Allegheny, lying in the Delaware River 2½ miles above Arnold's Point, N. J. Second Lieut. Spencer Cosby, U. S. Engr. Office.

DRAINAGE DITCH.—Princeton, Ind.—Efforts are being made to secure the construction of a drainage ditch about 10 miles in length and estimated to cost about $100,000; the ditch will be 40 ft. wide, with an average depth of 12 ft., and 20-year bonds will be issued to pay for the construction.

TUNNEL.—New York, N. Y.—The New York & Brooklyn Tunnel Co. has been incorporated with a capital stock of $100,000 to build an underground railway from a convenient point in New York, between East 16th St. and Whitehall St., under the bed of the East River, to a point in Brooklyn, between North Eighth St. and Atlantic Ave.,a distance of two miles; directors, Thos. A. Patterson, Jr., Chas. J. Schlegel, Walter J. Alms, John C. Bucken, Charles Kuehnmundt, John V. Bouvier, Jr., Frederick P. Delafield, Frank H. Knight, and Samuel S. Slater, of New York. Thos. A. Patterson, Jr., subscribes for 930 of the 1,000 shares of capital stock.

SHIP CANAL.—Warren, O.—A press report from this place March 4, states as follows: The preliminary survey for the ship canal to connect Lake Erie with the Ohio River at Pittsburg, was commenced here this afternoon by J. C. Oliphant and 12 assistants, who will cover the territory between Warren and the lake. Another party started at the same time and will work from the mouth of the Mahoning River to Warren, and a third starting from Conneaut Lake (Pa.), proposed feeder, will intersect the first party about 20 miles north of this city. About 2½ months will be required to make the surveys. All the corps are under the direction of a general committee in Pittsburg.

CONTRACT PRICES.

WATER-WORKS.—Fort Plain, N. Y.—The award of contracts for materials and construction of new water-works was noted last week under Water-Works. Boyd Ehle, Engr., writes us that the following bids were received from supply men for the materials:

Engr., writes us that the following bids were received March 7 for a lateral sewer, average cut 10 ft.; price per lin. ft. includes cost of manholes, basins and everything necessary for the full completion of the work; prices bid for manholes, basins, etc., are for any extra ones which may be required:

Bidder.	Manholes.	Basins.	Lamp-holes.	Per lin.ft.
Stephen Flanagan	.....	.....	.....	$1.72
Fahey Bros.	.....	.....	.....	1.61
Dunn Bros.	$59.00	$65.00	.....	1.98
Wm. Dunn & Co.*	78.00	85.00	$10.00	1.89
Fox & Duhigg	.....	.....	.....	1.70

* Wilkes Barre, Pa.; all others residents of Scranton.

BRICK PAVING.—Scranton, Pa.—Joseph P. Phillips, Cy. Engr., writes us that the following bids were received March 7 for paving Franklin Ave., from Spruce to Mulberry St., with vitrified brick on a concrete foundation:

Bidder.	Paving, per sq. yd.	Crosswalk grading, each.	Curb, per lin. ft.	Crosswalk, per lin. ft., 4 x 24 ins.	Circular curb, per lin. ft., 6 x 24 ins.	Old curb, reset.
Fred Heudler*	$2.38 to $2.43	$9.00	$0.62	$0.70	$0.96	$0.11
W. Dunn & Co.*	2.39 " 2.45	....	.58	....	.88	.12
Fox & Duhigg**	2.01and 2.08	....	.55	....	.85	.15
Fahey Bros**	1.96 " 2.07	....	.48	....	.78	.20
Dunn Bros.**	1.83 " 2.16	10.00	.55	.57	.80	.15

* Wilkes Barre, Pa. ** Scranton, Pa.

STEAM PUMP AND BOILER.—Willimantic, Conn.—Walter D. Brigham, Chn. Com., writes us that the following bids were received March 2 for a 2,000,000-gallon steam pump, with boiler, as advertised in Engineering News:

	—Cyl., diam., ins.— High.	Low.	Stroke, Water.	ins.	Prices.
Deane Steam Pump Co.	14	20	13½	18	$6,938
Barr Pumping Engine Co**	16	30	14	18	7,270
Henry R. Worthington	16	29	13⅞	18	6,395
Groshon H. D. P'p Eng. Co.*	18	36	8¾	30	14,000
Knowles Steam Pump Wks.	16	32	13½	24	8,998
Fraser & Chalmers	*20	32	12	..	14,893

* Not according to specifications.
** Awarded contract.

WATER-WORKS.—Ashland, O.—J. R. Strawn, Consult. Engr., has sent us the following report of the proposals received March 6 for material and labor for the construction of works, as advertised in Engineering News: Aggregate bids: Snyder & Williams, Day-

Bids Received at Fort Plain, N. Y., March 1, for Constructing Water-Works.

Bidder.	Ex-cav.	Emb'k-ment.	Rub. mas'y.	Con-crete.	Muck-ing.	Rip-rap.	Pud-dle.	Dam, per lin. ft.	—House.— 6 × 6-ft.	12 × 12-ft.	Foot bridge.	8-in. drain, laid.	Pipelaying. 10-in.	8-in.	6 in.	4-in.	Extra earth.	Rock excav.	Extra rock excav.	Total for const'n.
A. H. Coons & Son, Wilkes Barre, Pa.	$0.26	$0.39	$3.90	$4.50	$0.38	$0.80	$0.75	$4.90	$10	$55	$8	$0.27	$0.245	$0.22	$0.19	$0.16	$0.35	$1.65	$2.50	$19,854
Smith Bros., Pelhamville, N. Y.	.20	.26	7.50	5.00	.28	1.00	1.00	7.00	50	350	35	.30	.27	.24	.17	.14	.25	1.45	1.75	19,870
Troy Public Works Co., Troy, N. Y.	.50	.35	7.00	8.00	.35	1.25	2.00	10.00	100	200	25	.35	.35	.32	.25	.20	.35	2.00	4.00	26,326
W. B. Birdseye, Fayetteville, N. Y.	.25	.33	7.00	7.00	.25	1.00	.95	7.75	75	165	50	.35	.29	.26	.175	.15	.30	1.25	3.50	20,970
Beckwith & Quackenbush, Mohawk, N. Y.	.40	.32	7.00	10.00	.25	2.50	1.00	3.00	140	400	25	.32	.34	.27	.23	.20	.40	2.00	2.50	24,526
Seymour & Barber, Gloversville, N. Y.	.25	.35	5.00	6.00	.25	2.50	1.25	16.00	200	400	75	.40	.32	.27	.22	.20	.40	1.65	5.00	24,409
Lehigh Valley Const'n Co., So. Bethlehem, Pa.	.25	.40	4.00	6.00	.25	1.50	.95	6.00	50	205	75	.35	.275	.225	.20	.18	.30	1.75	2.50	21,432
A. Tubman, Cleveland, O.	.20	.27	5.75	4.75	.20	2.00	.95	17.00	15	800	75	.40	.26	.22	.18	.14	.45	2.00	2.75	24,347
Gallo & Cuozzo, New York	.30	.30	6.00	6.00	.30	2.50	.60	9.00	125	350	40	.50	.25	.24	.18	.14	.30	2.00	3.00	21,146
John Marsden, Utica, N. Y.	.30	.30	4.00	3.00	.25	2.00	.60	5.00	75	150	50	.20	.22	.21	.18	.16	.30	1.00	3.00	18,069
W. J. Fogg, Mount Vernon, N. Y.	.25	.32	6.00	6.00	.25	1.25	.65	8.25	60	275	30	.25	.23	.20	.17	.155	.30	1.90	2.50	19,052
W. O. Connivers & Co.	.30	.50	7.50	6.75	.30	2.50	1.00	10.00	50	500	25	.30	.33	.30	.25	.18	.40	2.00	2.50	26,052
Flood & Sherrill, Sandy Hill, N. Y.	.40	.35	6.50	9.00	.45	2.00	1.00	6.00	35	200	50	.30	.35	.25	.185	.155	.50	2.00	4.00	22,494
Hendrik, Taylor & Warner	.50	.30	6.00	6.00	.50	3.00	.75	7.00	50	400	25	.48	.35	.35	.20	.20	.50	3.00	5.00	27,768
P. H. Harrison & Sons, Newark, N. J.	.30	.45	6.50	7.00	.30	.85	1.25	7.50	60	300	50	.40	.37	.30	.20	.17	.30	2.00	3.00	25,275
Whitmore, Rauber & Vicinus, Rochester	.30	.25	11.50	5.00	.22	5.00	2.00	9.00	250	600	50	.35	.37	.34	.31	.29	.60	1.75	2.00	28,355
Gibney & Orendorf, Indianapolis, Ind.	.15	.185	3.00	3.00	.15	.97	.49	7.00	60	272	39	.285	.21	.165	.155	.14	.15	.47	.77	14,454
Geo. D. Grannis, Syracuse, N. Y.	.30	.30	6.00	9.00	.20	1.00	1.00	7.50	30	175	30	.40	.325	.24	.19	.17	.30	1.50	3.00	20,828
Paul Daino, New York	.30	.40	4.00	3.50	1.50	1.00	1.00	5.00	50	150	100	.40	.30	.23	.27	.26	.40	1.00	1.50	23,061

WATER TOWER.—Rochester, N. Y.—If the council makes the necessary appropriation the fire department will soon purchase a $5,000 water tower.

FIRE HOSE.—Portland, Me.—Chief Engineer Jackson has recommended the purchase of 8,000 ft. of fabric hose and 2,000 ft. of rubber hose.

WATER TOWER.—Toronto, Ont.—Bids are asked until March 18 for a water tower of the latest improved pattern, Geo. McMurrich, Chn. Com.

DRAINAGE DITCHES.—St. Paul, Minn.—The Red River drainage bill, appropriating $50,000 for additional ditches, has passed the House by a vote of 79 to 18.

DRAINAGE BONDS.—Piqua, O.—The county auditor is reported to have been directed to advertise for bids for the purchase of $14,000 of Ludlow joint ditch bonds.

MORTAR FORGINGS.—Washington, D. C.—Bids are asked until April 1 for six sets of steel forgings for 7-in. siege steel mortars. Gen. D. W. Flagler, Chief of Ordnance.

HOSE WAGONS, ETC.—Cincinnati, O.—Bids are asked until March 18 for 1 to 3 hose wagons, and one 75-ft. aerial extension ladder truck. W. T. Perkins, Secretary Fire Board.

GRADING.—St. Louis, Mo.—Bids are asked until March 20 for 900,000 cu. yds. of grading, as stated in our advertising columns. Pitzman's Co. of Surveyors & Engineers, 615 Chestnut St.

FIRE HOSE, ETC.—Manor, Pa.—The village has contracted for a water supply and is about to buy fire hose, carts, and other equipment for fire protection. W. F. Brinker, Town Clerk.

RAISING DAM.—Washington, D. C.—Work is about to be commenced on raising the Great Falls dam 2½ ft., for which Congress appropriated $125,000; 2,225 cu. yds. of stone will be required for the work.

WHARF WORK.—Washington, D.C.—Bids are asked until March 30 for repairing the wharf at the U. S. Quarantine station, Blackbeard Island, Sapelo Sound, Ga. Chas. E. Kemper, Acting Supervising Arch.

BREAKWATER, ETC.—Grand Rapids, Mich.—Bids are asked until April 4 for breakwater construction at Petoskey, Mich., and for pier extensions at Frankfort Harbor. Lieut.-Col. G. J. Lydecker, U. S. Engr. Office.

APPROACHES.—Lowell, Mass.—Bids are asked until March 27 for the construction of the approaches to the U. S. public building in this city. Address Chas. E. Kemper, Acting Supervising Arch., Washington, D. C.

DREDGING.—Wilmington, Del.—Bids are asked until April 5 for dredging Chester, Choptank, Warwick,

Bids Received at Fort Plain, N. Y., for Pipe, Valves and Hydrants.

Bidder.	—Pipe.— * $.	** $.	—Specials.— Ord'y. $.	Fig'd. $.	—Valves.— 10-in. $.	8-in. $.	6-in. $.	4-in. $.	Valve boxes. $.	Air valves. $.	Sluice gate, 12-in. $.	Gate and gear.— 10-in. $.	8-in. $.	4-in. $.	Hydrants. $.
Eddy Valve Co.(1)	.....	.....	.....	.....	22.75	16.00	10.25	6.60	2.50	5.00	35.00	27.00	21.00	12.00	21.65
John Fox	18.95	40.00	42.50	50.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Anniston Pipe Co.	19.40	.....	40.00	40.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R. D. Wood & Co.	20.25	22.50	60.00	.....	24.50	17.50	12.25	7.50	2.50	3.50	25.00	26.00	19.50	9.00	21.00
J. Thompson	.....	.....	.....	.....	23.00	16.25	10.25	6.60	2.50	4.50	35.00	33.00	26.75	16.75	21.50
Ludlow Valve Co.	.....	.....	.....	.....	23.00	16.00	10.60	6.40	2.75	10.60	30.10	35.60	28.35	18.55	21.75
Jonson Eng. & Fdry. Co.	20.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Crane Co.	.....	.....	.....	.....	20.00	14.50	8.75	5.75	2.00	4.50	37.50	27.70	21.75	12.25	20.50
McNeal Fdry. & Pipe Co.(2)	18.37	18.37	40.00	80.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
C. Millar & Son(3)	18.75	30.00	45.00	85.00	23.00	16.00	10.60	6.40	2.75	10.60	30.10	35.60	28.35	18.55	21.75

* 10 to 4-in. pipe, per ton of 2,000 lbs.; ** Ward's pipe, per ton.
(1) Awarded contract for hydrants and valves at $1,920 (itemized bid aggregates $1,299 for hydrants and $754 for valves).
(2) Lowest bidder for pipe, at $22,798, but could not guarantee delivery in time specified.
(3) Awarded contract for pipe, at $23,404.

CAST IRON PIPE.—St. Paul, Minn.—Jno. Caulfield, Secy. Water Comrs., writes us that the following bids were received March 8 for 20,000 ft. of 6-in., 3,500 ft. of 12-in., 9,228 ft. of 30-in. cast iron pipe, with privilege of additional purchase of 6, 12 and 30-in. pipe and 1,500 ft. of 16-in. and 300 ft. of 24-in. pipe:

	Per ton of 2,000 lbs. 6&12-in.	16-in.	24-in.	30-in.
Addyston Pipe & Steel Co.[1]	$29.93	$22.93	$20.93	$20.93
Chattanooga Frdy. & Pipe Wks.	20.30	20.30	19.80	19.30
Dennis Long & Co.[2]	21.73	21.73	20.43	20.43
Howard Harrison Iron Co.[3]	19.75	19.75	19.00	19.00
Anniston Pipe & Fdry. Co.	19.65	19.65	19.65	19.65
Shickle, Harrison & Howard Iron Co.[4]	19.23	.....	.....	.....

[1] $21.93 for entire lot. [2] $20.85 for entire lot. [3] Awarded contract for 16, 24 and 30-in. [4] Awarded contract for 6 and 12-in.

BRICK PAVING.—Rock Island, Ill.—A. D. Huesing, Cy. Clk., writes us that the following bids were received March 4 for paving several alleys with one course of Galesburg brick:

Bidder.	Paving.	Oak posts, set in place.	Tie rods.	Plank, curb, per M. ft.
J. B. McGorrisk	(1)	$0.25	$1.00	$20.00
McGugin & Schnitger(2)	$1.20	.17	.75	14.00
Wm. Atkinson	1.15	.12	.85	18.50
H. L. Wheelen	1.02	.10	.40	12.00
Edwards & Walsh Const'n Co.(2)	1.12	.20	1.00	20.00

(1) Des Moines brick, $1.01.
(2) Galesburg No. 2 brick, $1.05.

SEWERS.—Scranton, Pa.—Joseph P. Phillips, Cy. ton, O., $44,887 (awarded contract); Grimes & Moran, Elkhart, Ind., $48,904; Andrews & Shields, Hamilton, O., $47,238; Chandley Bros. & Co., Beaver Falls, Pa., $48,000; Mansfield & Allen, Indianapolis, Ind., $46,494. Pumping engines, John H. McGowan, Cincinnati, compound, $2,500; non-compound, $2,100; Laidlaw-Dunn-Gordon Co., Cincinnati, $2,000, $2,800 and $2,300; Hughes Steam Pump Co., Cleveland, $2,600; Barr Pump Co., Philadelphia, $1,935; Stilwell-Bierce & Smith-Valle Co., Dayton, $2,200 and $2,100; with boilers, $3,726. Boilers, two return tubular, Schriber & Co., Cincinnati, $1,678; Brownell Co., Dayton, $1,360; Mansfield Machine Works Co., Mansfield, $1,671; Aultman-Taylor Co., Mansfield, $2,693; water-tube boilers, $2,340. Stand-pipe, 20 × 75 ft., with foundation, Tippett & Wood, Phillipsburg, N. J., $3,569; Warren City Boiler Works, Warren, $4,100; Enterprise Boiler Works, Youngstown, $4,185; Variety Iron Works, Cleveland, $4,297; Brownell Co., Dayton, $3,941. Hydrants, Michigan Brass & Iron Works, Detroit, $22.20 and $22.15; Ludlow Valve Mfg. Co., Troy, N. Y., $21.50; Ripley-Detrick Co., St. Louis, $23; R. D. Wood & Co., Philadelphia, $23; Bourbon Copper & Brass Works, Cincinnati, $24 and $19; Crane Co., Chicago, $21.75 and $21.40; Richard Beaumont, Kankakee, Ill., $19.50. Cast iron pipe, Lake Shore Foundry, $19 per ton of 2,000 lbs.; special castings, 2 cts. per lb.; Addyston Pipe & Steel Co., $19.05; contractors' bids on pipe ran $19, $19.05, $19.15, $19.50, $18.65.

SEWERS.—Detroit, Mich.—A. McPherson, Secy. Bd. Pub. Wks., writes us that the contract for rebuilding the 18th St. sewer, 2,190 ft. of 3-ring brick, 8 ft. diameter, 7 manholes, has been awarded to Julius Porath at $8.53 per lin. ft.; manholes, $25 each; total, $18,440. The other bidders were: Lighardt & Winterhalter,

$8.85; Langley & Jeynes, $12.49; W. H. Collins, $10.92; John Jeynes, $10.25; John A. Mercier & Co., $11.25; John Duffield, $16.30 per ft. and $50 per manhole. Contracts have since been awarded for sewers as follows: Public sewer in Ferdinand Ave., 2,208 lin. ft., 5-ft. cylinder, 2-ring brick, 7 manholes, contract price $3.68 per lin. ft.; manholes, $30; total, $8,335. 31st St. public sewer, 3,338 ft., 10 manholes, size 3 ft. 7 ins. × 2 ft. 6 ins. to 4 ft. × 2 ft. 6 ins., 2-ring brick, contract price, $2.83 per lin. ft.; manholes, $30; total, $9,747. Rebuilding sewer in Hastings St., 4,943 lin. ft., size 5 ft. 6 ins. × 3 ft. 8 ins., 2-ring brick, 14 manholes; $4.61 per lin. ft., one drop chamber $70, 14 manholes $25 each; total, $23,207.

IRON AND WOOD STAKES.—Buffalo, N. Y.—The following bids were received March 6 for furnishing the bureau of engineering with oak and rock elm stakes during the year ending March 30, 1896: Heafner & Iguatz, $40 per M.; Tonawanda Planing Mill Co., $39.99; Jacob Hass, $38. The bids for wrought iron stakes were as follows: Frank Lenahan, $1.95 per 100 lbs.; Kellogg Steel & Iron Co., $1.74; Philip Wurtz, $1.86; Geo. H. Jones' Sons, $1.60 for ½-in. and $1.50 for ⅝-in.; Moore Mfg. Co., $3; Chas. F. Ernst, $1.60.

LEVEE WORK.—Shreveport, La.—The Caddo levee board has awarded the contract for 354,000 cu. yds. of levee work, from Magnolia to Grand Bend, at 12.74 cts. per cu. yd.

BRICK PAVING.—Easton, Pa.—H. R. Fehr, Cy. Engr., informs us that the contract for paving Northampton St., from Center Square to Fifth St., with vitrified paving brick upon a foundation of 6 ins. of concrete, has been awarded to J. E. Miles, at $2.01 per sq. yd. for McMahan, Porter & Co.'s repressed A brick, the bids being as follows:

BARBED WIRE.—Pittsburg: galvanized, $1.90; plain, $1.20 for carloads at mill.

FOUNDRY AND PIG IRON.—New York: $10.50 to $12.50. Pittsburg: $10 to $11. Chicago: $9.50 to $10.50.

TRACK MATERIAL.—New York: angle bars, 1.1 to 1.5 cts.; spikes, 1.45 to 1.6 cts.; track bolts, 1.75 to 1.85 cts. with square, and 1.9 to 2 cts. with hexagon nuts. Chicago: angle bars, 1.2 to 1.3 cts.; spikes, 1.6 to 1.7 cts.; track bolts, 1.9 to 2 cts., with hexagon nuts.

RAILS.—New York: $22 at eastern mills and $22.75 at tidewater; old rails, $11 to $11.50 for iron, and $9.50 to $10 for steel; steel rails fit for relaying, $14; light rails, $20 to $22; girder rails, $24. Pittsburg: $22 for standard sections of 45 lbs. and over; $23 for light sections; old rails, $12 to $12.50 for iron and $10 for steel. Chicago: $23 for standard sections; $25 for light sections; old rails, $10.50 to $11 for iron, and $7 to $9 for steel.

STRUCTURAL MATERIAL.—New York: beams, 1.3 to 1.5 cts.; channels, 1.35 to 1.5 cts.; angles, 1.2 to 1.35 cts.; tees, 1.4 to 1.6 cts.; universal mill plates, 1.2 to 1.35 cts.; steel plates, 1.2 to 1.3 cts. for tank, 1.35 to 1.45 cts. for shell, 1.5 to 1.65 cts. for flange, 1.75 to 2 cts. for ordinary firebox, 2 to 3 cts. for locomotive firebox. Pittsburg: beams, 1.2 to 1.5 cts.; channels, 1.2 to 1.5 cts.; angles, 1.1 to 1.15 cts.; tees, 1.2 to 1.25 cts.; universal mill plates, 1.05 to 1.15 cts.; steel plates, 1.1 to 1.2 cts. for tank, 1.2 to 1.25 cts. for shell, 1.25 to 1.3 cts. for flange, 1.75 to 2 cts. for ordinary firebox, and 2 to 4 cts. for locomotive firebox. Chicago: beams, 1.4 to 1.45 cts; channels, 1.4 to 1.45 cts.; angles, 1.3 to 1.35 cts.; tees, 1.65 to 1.7 cts., universal plates, 1.3 to 1.35 cts.; steel plates, 1.35 to 1.4 cts. for tank, 1.5 to 2 cts. for flange, 2 to 4.5 cts. for firebox.

Bids Received at Easton, Pa., for Paving with Vitrified Brick.

Manufacturer.	Grade of brick.	Geo. W. Rueh & Co., Philadelphia.	Lehigh Valley Const'n Co., H. O. Duerr, Man.	N. J. Paving & Const'n Co., Trenton, N. J.	Dunn Bros., Scranton, Pa.	Standard Const'n & Supply Co., Easton, Pa.	J. E. Miles, Easton, Pa.	Jas. McCloud & Co., Williamsport, Pa.	Sheard & Siebler, Easton, Pa.	Satterthwaite & Wynkoop, Phila.	M. Honan, Chester, Pa.	B. F. Sweeten & Son, Camden, N. J.
Mack Mfg. Co.....	Standard.*	.....	.....	$2.03	.....	$2.01	$1.93	$2.02	$2.20	$2.09	$2.05	$2.06
" " "	Repressed.	$2.34	.....	2.03	$2.20	2.09	2.04	2.06	2.315	2.14	2.07	2.12
" " "	Pat. block.	.....	.....	2.05	2.25	2.09	2.04	2.06	2.315	.....	2.07	.....
McMahan, Porter & Co...	Ordinary.	2.20	.....	1.94	.....	2.05	1.93	1.95	2.20	2.03	1.96	1.99
" " " " ..	Rep'sed "A."	2.28	.....	2.03	2.20	2.13	2.01	2.03	2.295	2.05	2.05	2.04
" " " " ..	" "B"	2.30	.....	2.05	2.25	2.15	2.03	2.05	2.315	.....	2.07	2.03
Campbell & Wood.....	End cut.	2.12	.....	.....	.....	2.00	.....	1.90	2.155	.....	.....	.....
Oliphant, Pope & Co.....	Repressed.	.....	$2.25	1.79	2.06	2.02	1.98	1.93	.....	.....	1.95	1.95
Monongahela Shale Brick	Standard.	2.28	.....	2.03	2.18	2.13	2.01	.....	2.295	.....	.....	.....
Scranton Shale Pvg.B. Co	Repressed.	.....	.....	2.15	1.94	.....	1.98	.....	2.155	.....	1.99	2.05
Canton Shale Exchange.	Repressed.**	2.35	.....	.....	.....	.....	.....	.....	.....	.....	2.13	.....
" " "	Standard.	2.29	.....	.....	.....	.....	.....	.....	.....	.....	2.07	.....
Somerset & Johnsonburg.	Repressed.	2.22	.....	.....	2.18	.....	.....	.....	.....	.....	2.03	2.09
" " "	Standard.	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.97	.....
Brady Run Fire Clay Co.	Standard.	2.33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Clearfield Vitrified Brick.	Repressed.	.....	.....	.....	.....	.....	1.98	.....	.....	1.95	.....	.....
Kountz Shale Brick.....	Standard.	.....	.....	1.99	2.12	2.09	1.97	2.02	.....	.....	2.01	2.03
Keystone Brick Co.....	Standard.	.....	2.28	.....	.....	.....	.....	.....	.....	2.06	2.05	2.02
" " "	Repressed.	.....	2.35	.....	.....	.....	.....	.....	.....	.....	2.11	2.05
Hallwood Block	Repressed.	.....	.....	.....	.....	.....	.....	2.05	.....	.....	.....	.....
D. P. Guise Brick.....	.....	.....	.....	.....	.....	.....	.....	1.97	.....	.....	.....	.....
Canton Royal Brick Co..	Block.	.....	.....	.....	.....	.....	.....	2.19	.....	.....	.....	.....
" " " " ..	Repressed.	.....	.....	.....	.....	.....	.....	2.21	.....	.....	.....	.....
" " " " ..	Standard.	.....	.....	.....	.....	.....	.....	2.10	.....	.....	.....	.....
4-in. curb, per lin. ft.....		.48	.65	.50	.58	.50	.55	.48	.45	.49	.65	.45
Curb reset, per lin. ft.....		.08	.50	.10	.22	.25	.25	.15	.25	.15	.12	.10

* Edward Korp, Phillipsburg, N. J., bid $2.23 on Mack Mfg. Co.'s standard brick; curb, 45 cts.; curb reset, 10 cts. ** The Pennsylvania Construction Co., Allentown, Pa., bid $2.45 on Canton Shale Exchange's repressed brick; curb, 60 cts.; curb reset, 25 cts. Geo. F. Rehn & Co., Hornellsville, N. Y., bid $2.10 on Preston & Co.'s brick; curb, 40 cts.; curb reset, 15 cts.

CAST IRON PIPE.—Brockton, Mass.—The water commissioners have awarded a contract for 230 tons of cast iron pipe to the McNeal Foundry & Pipe Co., at $22.80 per gross ton, delivered in Brockton. This is reported as 9 cts. less per ton than was paid last year.

HYDRANTS.—Milwaukee, Wis.—A contract for 125 double-nozzle fire hydrants has been awarded to the Northwestern Wheel & Foundry Co., at $26 each.

GRANITE PAVING BLOCKS.—Boston, Mass.—A contract for 300,000 large granite paving blocks has been awarded to the Rockport Granite Co., at $57.90 per 1,000 blocks.

SEWERS.—Cedar Rapids, Ia.—The contract for constructing a four-ring brick sewer 12 ft. in diameter in E. Ave. West, has been awarded to the Dubuque Construction Co., the bids being as follows:

	Sewer, per lin. ft.	Masonry, per cu. yd.	Total.
Dubuque Construction Co..	$10.20	$5.95	$4,444
Berry & Welch, Iowa City.	17.46	6.00	6,588
Fred Bokorney.....	25.00	6.25	8,905
H. Bessler.....	24.55	3.50	8,152
Murray Bros.....	24.00	6.50	8,652

BRICK PAVING.—Waterloo, Ia.—H. C. Schults, Cy. Clk., writes us that the following bids were received Feb. 25 for paving certain streets with two courses of brick, all the bids being rejected and new bids to be received March 11:

Bidder.	Galesburg, 2 courses.	Des Moines, 2 courses.	Extra excav., per cu. yd.	Berea curbing, per lin. ft.	Stone City curbing, per lin. ft.
	$	$	cts.	cts.	cts.
Kenety & McCann, Dubuque.....	1.42	30	51	50	
Geo. Kriechbaum, Burlington.....54	1.47	20	49½	47½	
Rockford (Ill.) Const'n Co.....1.58½	1.48½	35	47	45	
Edwards & Walsh,* Davenport....1.43	1.31	5	47	46	
McGugin & Schnitzer,** Davenport1.54	1.39	00½	47	45	
H. L. Wheelan, Rock Island....1.41	1.31	..	42	42	
H. Besler,*** Cedar Rapids....1.56	1.43	..	50½	48½	

* Galesburg top, Lehigh bottom, $1.44. ** Galesburg top, Des Moines, bottom, $1.49½. *** Two courses, Fort Dodge, $1.32½; Galesburg top, Lehigh bottom, $1.51.

METAL MARKET PRICES.

LEAD.—New York: 3.07 to 3.1 cts. Chicago: 2.9 to 2.92 cts. St. Louis: 2.95 cts.

NAILS.—Pittsburg: 90 cts. for wire, and 80 cts. for cut at mill in carload lots.

INDUSTRIAL NOTES.

THE BUFFALO CAR MFG. CO., of Buffalo, N. Y., has an order for 1,500 box freight cars for the New York Central R. R.

THE FIELD FORCE PUMP CO., of Lockport, N. Y., had its building destroyed by fire March 8, involving a loss of $25,000.

THE ERIE CAR WORKS, of Erie, Pa., has been purchased by William Hamilton and John C. Knoll, and it is reported that the plant will be rebuilt.

THE WESTINGHOUSE MACHINE CO., of Pittsburg, Pa., will erect new shops at East Pittsburg, and proposals for their construction were opened March 11.

THE ATLANTIC PAINT WORKS, Boonton, N. J., are manufacturing a paint from furnace slag which is said to be specially suitable for ironwork, bridges, boilers, and smokestacks.

HENRY R. WORTHINGTON, New York, N. Y., has a contract from the New Haven Water Co., of New Haven, Conn., for a horizontal, high-duty pumping engine of 10,000,000 gallons daily capacity, which is to be in operation in July.

THE MISSOURI DREDGE CO., of Kansas City, Mo., has been incorporated by W. T. Urie, N. M. Martin and W. M. Martin, with a capital stock of $10,000. This was incorrectly noted as the Kansas City Dredge Co. in our issue of last week.

THE BABCOCK & WILCOX CO., of New York, has a contract for boilers aggregating 2,000 HP. for the Johnson Co.'s new steel works at Lorain, O. The headers are to be of steel and the boilers will carry a working pressure of 200 lbs. per sq. in.

MORAN BROS., of Seattle, Wash., have notified the Navy Department that they have a plant and equipment of sufficient capacity for the construction of torpedo boats, and the firm will probably bid on some of the boats provided for by the new navy appropriation bill.

THE INDIANA OOLITIC STONE CO. has been organized by a number of quarry owners to maintain standard prices and to push the introduction of oolitic stone for buildings. Pres., A. C. Voris, of Bedford, Ind.; Treas., Ira C. Bateman, Bloomington, Ind.; Secy., J. O. Finks, Bedford, Ind.

THE GOULD'S MFG. CO., of Seneca Falls, N. Y., has a contract for a pumping plant of 3,000,000 gallons daily capacity for the water-works at Canandaigua, N. Y. The pumps will be of the triplex type, with cylinders 12 × 12 ins., and will be situated on the shore of Canandaigua Lake, being driven by electric power from a central station in the city, 3½ miles distant.

J. M. MAYS & CO., of Philadelphia, Pa., makers of the patent chilled point pile shoes with bent wrought iron straps, illustrated in our issue of Sept. 20, 1894, are now making these shoes in a variety of sizes and weights as follows: Octagonal point, 5½ to 7 ins. base of pile, 2 5to 54 lbs.; square point for 4 to 6½-in. piles, 14 to 47 lbs.; steel pile shoes, 9 to 11 ins., 17 to 50 lbs.

THE MARYLAND STEEL CO., of Sparrow's Point, Md., has nearly completed the iron gates for the locks on the Cascades Canal of the Columbia River, in Oregon. There are four pairs of gates, each gate being 50 × 50 ft. and weighing about 120 tons. This company has the contract for boilers and a Corliss engine of 1,000 HP. for the new tinplate works of the Stickney Iron Co., at Baltimore, Md.

THE AUTO-PNEUMATIC RAILWAY SIGNAL CO., of Rochester, N. Y., writes us that its new pneumatic interlocking plant at Mt. Morris, N. Y., on the Delaware, Lackawanna & Western R. R., at the junction of the Western New York & Pennsylvania R. R. is about completed. We are informed that it is in many respects an improvement over the Buffalo plant, described and illustrated in our issue of Dec. 21, 1893.

THE ALEXANDER CAR REPLACER MFG. CO., of Scranton, Pa., is introducing a pressed steel car replacer or wrecking frog, which is already in use on a number of railways. The No. 1 size is high enough for a 6-in. rail, weighs 120 lbs. per pair and costs $15; while the No. 2 size is high enough for a 5-in. rail, weighs 100 lbs. per pair, and costs $14. Pres., Jos. J. Jermyn; Vice-Pres., R. B. Williams; Man., John A. Mears; Treas., John T. Richards.

THE BERLIN IRON BRIDGE CO., of East Berlin, Conn., has designed and built the new power plant for the Nassau Electric Co., at South Brooklyn, N. Y. The engine and dynamo room is 58 × 150 ft., equipped with a 13-ton crane, having a travel the full length of the building. This portion of the plant is covered with the company's patent anti-condensation corrugater iron roof lining. The boiler room is 47 × 150 ft., and is so arranged that 2,000 tons of coal can be stored in the pockets. The entire construction is of iron, and the buildings will be fire-proof.

THE WILSON & BAILLIE MFG. CO., of Brooklyn, N. Y., states that its business for last year showed a large increase over former years, and the prospect for 1895 is that the business will largely exceed that of 1894. The firm has orders in hand for 15 miles of patent machine made, egg-shape, flat-base sewer pipe, and many large contracts for its Kosmocrete pavements, notably the Brooklyn Bridge work, State Armory at Utica, fire engine houses for the Fire Department of Brooklyn, University Building, New York; water tower building, Brooklyn, and other large work.

NEW COMPANIES.—Improved Asphalt Pipe Co., Bakersfield, Cal., $300,000, all paid in; H. F. Williams, John M. Keith and J. J. Mack.

National Stock Car Co., Chicago, Ill.; $600,000; Wm. W. Smith and Lucien H. Green.

Loew Filter Co., Cleveland, O.; $10,000; Chas. H. Loew, Fred Bomonti and Leonard Balby.

Railroad Supply Co., Chicago, Ill.; $1,000; W. E. Duncan, W. N. Wegg and D. M. Spencer.

York Mfg. Co., York, Pa.; iron and steel work; $400,000, with $40,000 paid in; Treas., Wm. L. Gratfelter.

Ewbank Car Fender Co., Baltimore, Md.; $150,000; Wm. J. Sneeringer, H. B. Ewbank and F. N. Baker.

Indiana Oolitic Stone Co., Bloomington, Ind.; Pres., A. C. Voris, of Bedford; Secy., J. O. Finks, of Bedford.

National High-Duty Pumping Engine Co., Chicago, Ill.; $100,000; A. H. Matheslan, C. F. Smith, and A. J. Meyer.

Cayadutta Brick Co., Gloversville, N. Y.; $60,000; Curtis S. Cummings, Oscar L. Everest and Albert M. Banker.

Twin-Chemical Fire Engine Mfg. Co., Kansas City, Kan.; $20,000; J. A. Clark, Geo. J. Twist, and Wm. Morrow.

Berlin Machine Works, New York, N. Y.; $2,000; W. O. Gantz, Edgar W. Youmans, Jr., and Henry R. Johnson.

Lake Superior Elevator & Storage Co., West Superior, Wis.; $10,000; Jas. Bardon, P. S. Butler and C. L. Catlin.

National Elevator & Machine Co., Scranton, Pa.; $20,000, with $2,000 paid in; elevators; Treas., James S. McAnulty.

South Green Bay Land & Dock Co., Madison, Wis.; $1,000,000; James H. Elmore, F. A. Hollman and Frank Van Derger.

Estey Wire Works Co., New York, N. Y.; $25,000; W. S. Estey, Cornelius P. McGuire, and John C. Hessler, of Brooklyn, N. Y.

War & Naval Appliances Mfg. Co., Chicago, Ill.; $25,000; armor plates; John F. Ballinger, Rome B. Pullan and C. W. Haegg.

Iron Clad Rheostat Co., Franklin, N. J.; $25,000, with $10 paid in; Jas. D. McIntosh, of Franklin, and C. Fales, of Hoboken, N. J.

River Furnace & Dock Co., Cleveland, O.; $100,000; blast furnace, dock, etc.; Stevenson Burke, James Corrigan, and C. W. Marsh.

Faultless Gas Saver Co., San Francisco, Cal.; $100,000, with $50,000 paid in; E. J. Norris, A. K. Stevens and N. S. Femburg.

New Jersey Gas Appliance Co., Hackensack, N. J.; $50,000, with $40,000 paid in; George Clair, Edwin Wickstead and C. W. Biglow.

Brandenburg Under-Car Electric Railway Co., Chicago, Ill.; $5,000,000; George Brandenburg, Geo. W. Van Zandt and Wm. A. Youmans.

Sutherland Pulverizer Co., New York, N. Y.; $100,000; pulverizing and amalgamating machines; James Sutherland, I. L. V. Lewis and H. F. Gove, of Brooklyn, N. Y.

Finance & Construction Co., Jersey City, N. J.; $100,000, commencing with $1,000; Jas. D. Shields, Paterson, N. J.; Henry Frohwitter and Michael Jacobs, of Brooklyn, N. Y.

Montezuma Mining & Mfg. Co., New York, N. Y.; $500,000, commencing with $100,000; Charles Andrews, of Zanesville, O.; T. D. Dale, of Marietta, and W. F. Dana, of Belpre.

Laurentian Lumber Co. of Canada, New York, N. Y.; $350,000; George W. Robinson, James D. Leary and Eugene J. Swan, of New York; William Borthwick, of Ottawa, Ont.

North Stockton Townlot Co., Stockton, Cal.; $200,000, all paid in; streets, sewers, electric railways, etc.; John N. Gale, of Stockton; William Kaiser, Max H. Greenburg and Robert Capelle, of San Francisco.